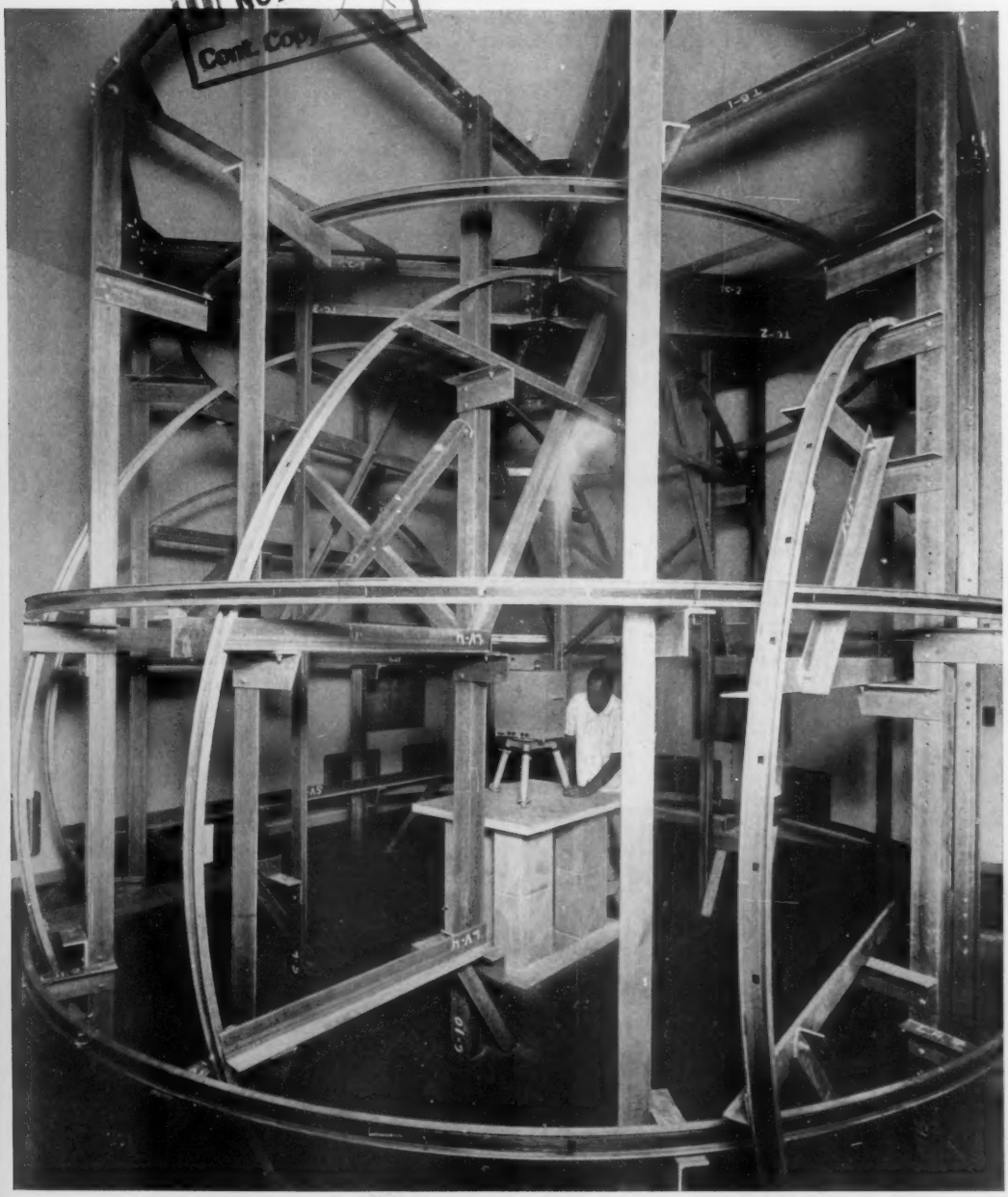
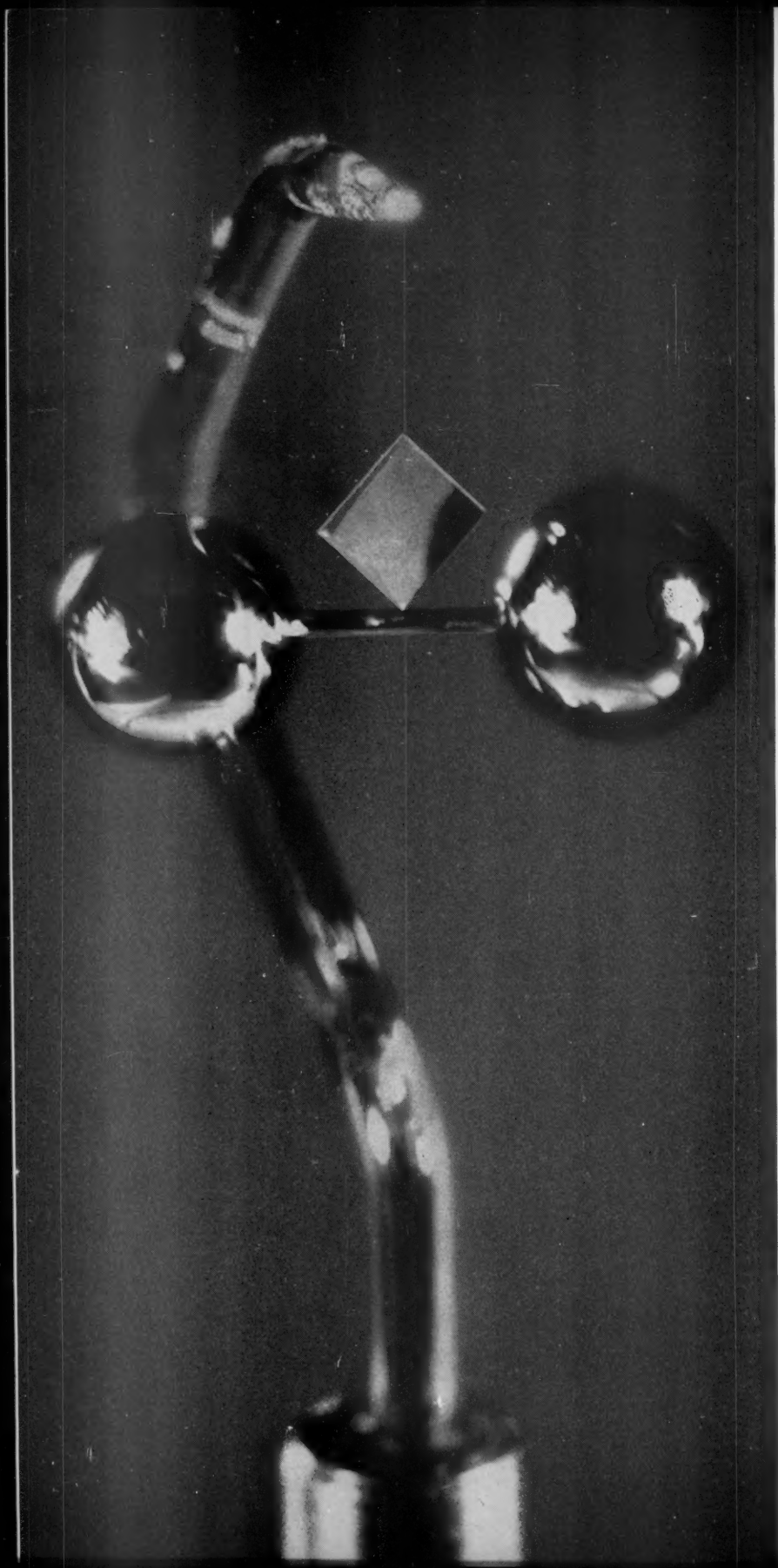
SCIENCE

6 November 1959

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



SCIENCE is published weekly by the AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Second class postage paid at Washington, D.C., and additional mailing office. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.



ACTUAL PHOTO ENLARGED 16 TIMES

The rugged dumbbell with oxygen sensitivity...

this unique paramagnetic measuring unit — ruggedly mounted in all Beckman Laboratory Oxygen Analyzers — provides superior sensitivity, specific to oxygen. This gives you rapid measurements of static or flowing gas samples (as small as 3 milliliters) with precise readings in percent oxygen or partial pressure. For critical analyses in the research lab or on process streams...when you must be sure 0_2 is absent... or controlled to a specific level... or determined in a varying sample...you can rely on Beckman analysis for purity, safety or quality control. Convenient sales and engineering service is available through your nearby Beckman dealer. For detailed information, write for Data File 38-45-05.

Beckman®
Scientific and Process Instruments Divisi
Beckman Instruments, Inc.
2500 Fullerton Road,
Fullerton, California

It's a Fact: **With Beckman's new Megachrom* Preparative Gas Chromatograph, you get 100X larger samples — up to 99.9999% pure.**
*T. M.

Visit Booth 333 at the Chem Show

6 November 1959, Volume 130, Number 3384

SCIENCE

Cover Braunbek coil array used for producing directed magnetic fields up to 1 oersted at the Fredericksburg, Virginia, Magnetic Observatory and Laboratory of the U.S. Coast and Geodetic Survey. In the working space over the pierhead, the applied field neutralizes or modifies the earth's field to simulate that of any locality on the globe or in outer space. [Courtesy U.S. Coast and Geodetic Survey]

Charles Darwin...on evolution

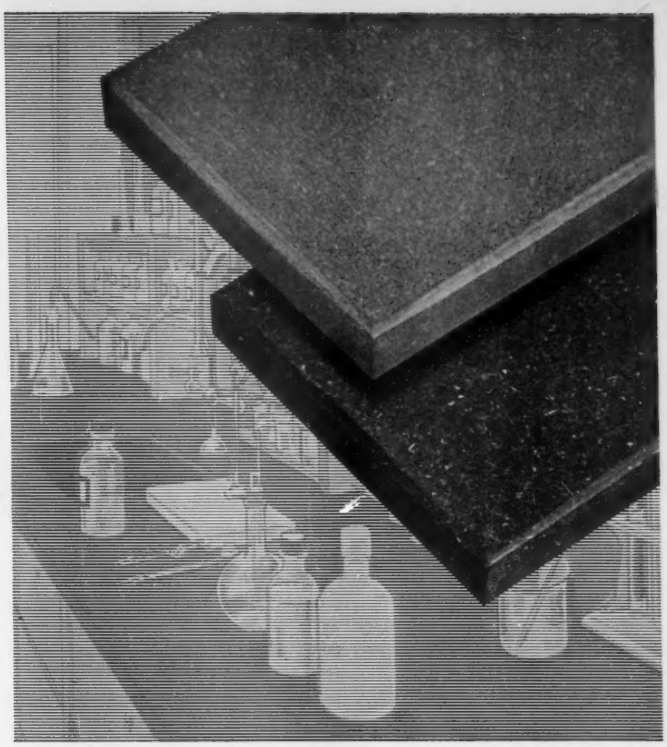
"It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been produced by laws acting around us.... Thus, from the war of nature, from famine and death, the most exalted object we are capable of conceiving, namely, the production of the higher animals, directly follows. There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved."

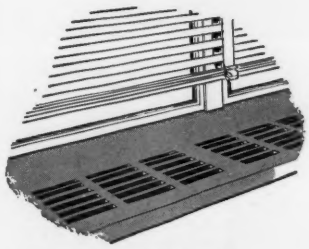
—*Origin of Species*, 1859

Now—

a touch of beauty that wears like stone

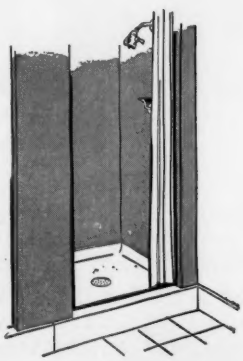
on many hard-working surfaces





Window sills of Colorlith are pleasing to the eye...won't warp under prolonged heat or moisture.

Colorlith gives washroom wainscots a bright new lift. Stays attractive... resists moisture, chipping, abuse.



Ideal for shower stalls.. strong, rigid Colorlith can't warp, rust, rot or corrode.

J-M COLORLITH®...handsome, tough, colorful

Created as an attractive, lower cost material for laboratory table tops, Colorlith has now gained wide acceptance as a surfacing material in many busy interior areas.

Fabricated from asbestos fiber, portland cement and chemically resistant colorings, this inorganic material resists heat, flame, moisture, even acids and solvents in normal working concentrations, when properly coated with a clear lacquer or equivalent. Color runs all the way through the sheet. Thicknesses from 1¼" down to ¼" can be used without breaking.

Write for Colorlith specification sheet EL-94A and brochure EL-62A. Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

JOHNS-MANVILLE

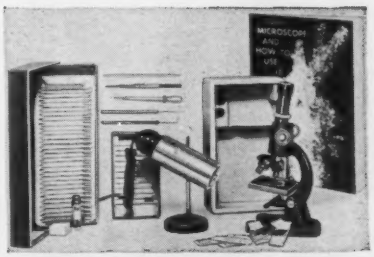
The SCIENCE MATERIALS CENTER presents

Gifts every Santa will want to share with his children

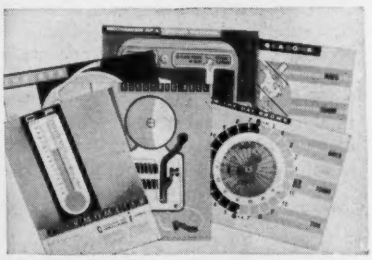
- **Fascinating 'portable laboratories'**
- **Pre-tested • Age-graded**
- **Created in consultation with leading scientists and educators**

PRE-ELECTRICITY PHYSICS LAB (#1245)
Materials for over 100 experiments and projects demonstrating the basic principles of magnetism and static electricity. Includes alnico magnets, compasses, neon bulbs, ores, two 48-pg. manuals. Ages 10 up. **$5.95**

CALCULO ANALOG COMPUTER (#0220)
Dozens of fascinating problems in mathematics and physics can be solved with this new analog computer. With 36-pg. manual—a complete introduction to the basic principles of computer theory. Ages 12 up. **$16.95**



MICROSCOPE LAB (#0500)
An ideal introduction to microscopy, slide preparation and photomicrography. Kit contains superior imported microscope, 32-pg. *Your Microscope and How to Use It*, and ten essential accessories. Ages 12 up. **$19.95**

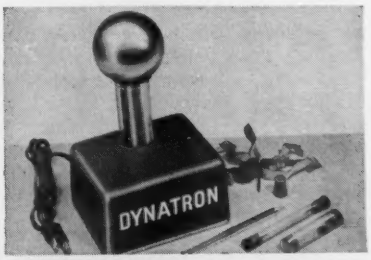


MOTOGRAPH SCIENCE CHARTS (#1238)
Unique set of 6 charts with movable parts—can be assembled to show basic scientific principles in action. Subjects include the human eye, electric bell, thermometer, etc. With manual. Ages 10 up. **$9.00**

BRAINIAC K-30 (#1119)
New, improved version of the famous "electric brain" construction kit. Illustrates many absorbing digital computer circuits—reasoning, mathematics, puzzle-solving, etc. Exclusive 64-pg. manual. Ages 12 up. **$18.95**

ULTRA VIOLET SCIENCE LAB (#0126)
The theory of fluorescence—and its applications in many areas of research—dramatized by nearly 50 experiments that can be performed with aid of accompanying manual, *Story of Black Light*. Ages 12 up. **$11.95**

SPACE SONGS (#0312)
12" long-playing (33⅓ rpm) record of delightful songs about the moon, the sun, the stars, etc.—to stimulate scientific curiosity in children. With songbook, arranged for piano. Ages 6 up. **$5.95**



DYNATRON (#1127)
Fully assembled miniature Van de Graaff generator affords an intriguing course in basic electronic concepts. Produces harmless 75,000 volt charge. Manual of 40 experiments. Ages 10 up. **$19.95**

SCIENCE MATERIALS CENTER, Dept. M-48
59 Fourth Avenue, New York 3, N. Y.

Please send me the items listed below, for which I enclose payment. I understand that if not delighted, I may return this merchandise within 10 days for a full refund.

Quantity	Name of Item and No.

Name_____

Address_____

City_____ State_____

Letters

On the Two Cultures

I was especially interested in the comments of C. P. Snow, printed as an editorial in *Science* [**130**, 419 (21 Aug. 1959)]. Those of us in the science teaching field are reminded of the existence of the two cultures both by our association with colleagues who represent each of them and by student comments and attitudes.

Some years ago William James wrote an essay entitled "On a certain blindness in human beings." While having been very much aware of this blindness for a long time, I am still disturbed after more than 35 years of college teaching to see how little impact scientific ideas have had on some segments of the college community. I was forcibly reminded of this on two occasions last year when students who were being subjected to the requirement of some course work in science while majoring in a humanities area protested inclusion of factual material in examinations. One of these students commented that as an English-journalism major he was taught to "think in ideas rather than in facts." The same student objected to scientific writing being couched in technical terms.

There is also the attitude on the part of humanities and even of some social-science specialists that scientists are a rather uneducated group, that real education consists of knowledge of literature and philosophy, acquaintance with which is mandatory, whereas ignorance of science somehow enhances one's intellectual respectability. A short time ago I heard a philosopher speaking over a television network. While admitting that science was one way of looking at the world, he seemed to think of it as a rather distorted one, and of philosophy as the true way.

We scientists are not guiltless. I find some of my scientific colleagues using *liberal arts* as a term of opprobrium, designating those who have the one culture, to which "science" is much superior. We have also placed some rather formidable hurdles before the aspirant to scientific knowledge and have sometimes assumed that unless he is capable of understanding in the critical sense the mathematical jargon in which some scientists must express their findings, he is incapable of understanding what the scientist is about. We have often looked upon the man who attempts to translate scientific information into the less rigid terminology of the layman as almost guilty of desecration.

The gap needs bridging. The vocabularies of both groups need to be expanded to include reading knowledge of the other culture's literature. This is a very real challenge to both groups and especially to those who try to teach at the undergraduate level. Wordsworth might write that he would rather be "a pagan, suckled in a creed outworn," but he could not be, any more than Thoreau could live in complete independence at Walden Pond.

GEORGE M. ROBERTSON
Grinnell College, Grinnell, Iowa

Your quotation from Sir Charles P. Snow properly points out the serious shortcomings of science education. But I feel that it is incorrect in one important respect.

Sir Charles assumes that there is a substantial proportion of intelligent people who are incapable of grasping mathematical concepts. A similar view is held by many concerning the existence of people who are ineducable in science. Although a certain amount of such ineducability is probably inevitable, I think that the extent of it is grossly overestimated.

There was a time only three centuries ago when a majority of the population was considered incapable of mastering the 3 R's. Long division was at that time a college subject.

Science and mathematics education are at a similar early stage of development. Almost no real science is taught until age 12. Thereafter, science education (and to a lesser degree mathematics education) is hit-and-run, improperly presented, and generally inadequate. It is largely taught as a mass of facts. Experimentation, observation, and critical thinking are almost totally absent. In many schools mastery of terminology is sufficient to pass an objective test, a poor substitute for real science.

Techniques and materials have been developed to arouse curiosity and interest and challenge children's abilities at an early age. But these techniques and materials are not yet in widespread use.

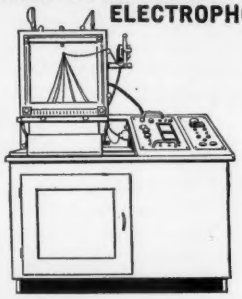
For example, for many young people experiments with magnets and simple circuits at age 6 will do more to develop scientific attitudes than hours of book study at age 16. Cutting and pasting cardboard tetrahedrons and prisms instead of paper dolls, and making interesting designs with ruler and compass can prepare a child for a smooth transition to formal geometry. Simple puzzles and interesting experiments will help to lay the basis for satisfying successful experiences and serve to prevent future mental blocks and failures.

Until proper techniques of science and mathematics education are actually in widespread use at school and at home, it is too early to think in terms

ARE YOU UP-TO-DATE ON SCIENTIFIC INSTRUMENTATION?

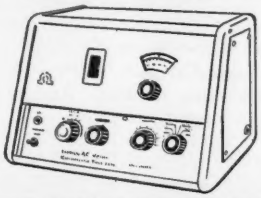
A condensed outline of developments recently introduced and now available from BRINKMANN and affiliated distributors.

CONTINUOUS PAPER ELECTROPHORESIS:



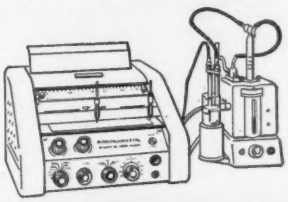
The successful application of "curtain" electrophoresis to problems of continuous separation has led to the development of the new ELPHOR VaP with greatly increased capacity. It is now possible to process 6 to 8 grams of albumin derivatives or up to 40 grams of serum per day with improved purity of the collected fractions. (Circle 1)

RESEARCH pH METERS:



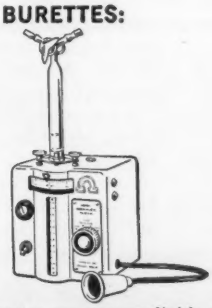
The new Metrohm line operated Compensator E322 combines versatility with maximum stability and a sensitivity of 1/100 pH. AC amplification and electronic ZERO indicator, automatic temperature compensation for blood pH are some of the features of this apparatus. (Circle 2) For FAST operation and RECORDING, there is the new DUAL range E300. (Circle 3) Micro and Macro CAPILLARY electrodes have been designed for these instruments. They may also be used with pH meters of other makes. (Circle 4)

AUTOMATIC RECORDING TITRATOR "POTENTIOGRAPH":



Here is the most universal instrument for pH, mV, amperometric, coulometric and Dead Stop titrations. Featuring motor burettes synchronized with the recorder and a wide range of current and voltage scales, the POTENTIOGRAPH is suitable for RESEARCH as well as ROUTINE work. (Circle 5)

MOTOR BURETTES:



Motor Burettes are now available for ordinary and radio-active solutions. Greater speed, better accuracy and superior operating convenience are some of the advantages of these novel titrating aids. (Circle 6)

TEMPERATURE CONTROL:

Equipment used for this purpose is often as antiquated as it is inefficient. Brinkmann-HAAKE ULTRATHERMOSTATS are truly modern. They are designed to save space which is often at a premium, and to give maximum efficiency. UNITHERM is a NEW Suspension Thermostat which doubles as a circulator. The COMPACT Type F, now in non-corrosive PLASTIC housing, is a self-contained, surprisingly small unit. There are also the LARGE N-types for temperatures to 300°C and greater capacities. (Circle 7)

WEIGHING:

Introducing a FAST Single PAN Semi Micro SELECTA, the NEW S M R, capacity 100 grams, accuracy ±.02 mg 15 seconds weighing time (Circle 8), and the brand new SARTORIUS KILOMAT III, a precision balance with 3000 grams capacity, instantaneous reading on a projection scale and without any external weights. (Circle 9)

BRINKMANN

Space being limited we can mention only a few additional items which may be of interest, viz: ZEISS Fluorescence Microscope (Circle 11), Swift VERNIER Micro-and Telescope for horizontal and vertical measurements (Circle 12), Automatic BIO-Assay Apparatus (Circle 13) and JUMBO Contact Thermometers (Circle 14). Also the All Quartz Bi-Distiller for pyrogen free aqua distribution (Circle 15) and Climatic Chambers with temperature range from —90° to +90°C (Circle 17).

C. A. BRINKMANN & CO., INC. 12 11
115 CUTTER MILL ROAD GREAT NECK, L. I., N. Y.
Please send me free and without obligation the Bulletins I have circled below.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE____

of large numbers of otherwise intelligent people being unable to grasp fundamental ideas in mathematics and science.

HY RUCHLIS
Science Materials Center, New York

Publications and Basic Research

In his article "Basic research in industry" J. C. Fisher [*Science* **123**, 1653 (1959)] attempted to gauge the extent of basic research in U.S. industry by a count of scientific publications. I suggest that Fisher's basic assumption may contain a much larger error than he recognized.

Fisher assumes that a count of publications gives a "relatively good picture of the quantity and distribution of basic research effort." He also states, "Publications were counted indirectly, by counting abstracts . . . in the 1955 volume of *Chemical Abstracts*. . . . It is only approximately true that *Chemical Abstracts* finds and abstracts all publications concerned with basic research and rejects all publications concerned with applied work. However, the proportion of abstracts dealing with applied work appears to be *reasonably small and invariant*" (italics mine). It is this latter premise which my associates and I question.

Through the courtesy of Fisher, we obtained a list of the titles of those articles which he counted in the 1955 volume of *Chemical Abstracts* for Esso Research and Engineering Company, Humble Oil and Refining Company (which carries out research and development under contract to Esso Research), and two other leading petroleum research organizations. We have analyzed the articles so listed and find that the bulk of these articles would, in our opinion, be classed as other than basic research. Furthermore, the proportion of papers which we would class as basic research varies greatly, from about 10 to 48 percent of the total listed in *Chemical Abstracts*.

Fisher's tabulation of papers for Esso Research and Engineering Company also was incorrectly low, due to his assignment of ten Esso Research papers to Standard Oil Company (Indiana). A paper originating from Standard Oil Company of Ohio was also attributed to Standard Oil Company (Indiana). These errors perhaps arose because various companies use the Standard Oil name. The papers appearing in 1955 *Chemical Abstracts* were published from the Standard Oil Development Company, the predecessor to Esso Research and Engineering Company.

A final comment—there has been a marked increase since 1953-54 in the amount of basic research being done by private industry. I am sure Fisher would be the first to suggest that this subject warrants an up-to-date and quantitative analysis.

W. T. KNOX
Esso Research and Engineering Company, Linden, New Jersey

I wish to thank W. T. Knox for finding the error in Table 1 of my article, wherein ten papers belonging to Esso Research and Engineering Company were mistakenly attributed to Standard Oil Company (Indiana). The wrong figures were

Rank	*Company*	*No. of publications*
13	Standard Oil (Indiana)	48
48	Esso Research and Engineering	13

The correct figures are

Rank	*Company*	*No. of publications*
15	Standard Oil (Indiana)	38
28	Esso Research and Engineering	23

The change affects the position of Standard Oil (Indiana) relatively little, moving it from 13th to 15th position. Esso Research and Engineering is more significantly affected, moving from 48th to 28th position. The error came about because Esso Research and Engineering changed its name from Standard Oil Development during the period covered by the study, and the earlier name did not appear in my check list of companies and affiliates (*Poor's Register of Directors and Executives, 1956*). I extend my apologies to Esso Research and Engineering for the error.

The Standard Oil of Ohio paper mistakenly attributed to Standard Oil (Indiana) seems to be an example of the random errors that arose because of company names that were missing, wrong, or incompletely given in *Chemical Abstracts*.

The assumption that a reasonably small and invariant proportion of abstracts dealt with applied work is not as good as I had thought, and I must agree with Knox's criticism of this point. My associate, J. B. Newkirk, has made an independent study of this matter and feels that only about half of the chemistry research and two-thirds of the physics research was properly classifiable as basic. Although the proportion of basic work abstracted by *Chemical Abstracts* is smaller than I had thought, I believe that the general conclusions of the study remain valid. Certainly a more up-to-date study is in order to show the considerable growth of basic research in industry since 1954.

JOHN C. FISHER
General Electric Company Research Laboratory, Schenectady, New York

GET READY FOR THE SPACE and SCIENCE ERA! SEE SATELLITES, MOON ROCKETS

AMAZING OPTICAL BUYS

and OTHER SCIENTIFIC BARGAINS

EXCELLENT for XMAS GIFTS!

American Made — Terrific Buy!
Over 50% Saving
STEREO MICROSCOPE

Years in development. Equals $300 to $400 instrument. Precision American made. Used for checking, inspecting, small assembly work. Up to 3" working distance. Clear, sharp, erect image. Wide, 3 dimensional field. 2 sets of objectives on rotating turret. 23X and 40X. 10 Days Free Trial.

Stock No. 85,056-W ---------$99.50 f.o.b. Barrington, N.J.

Low Power Supplementary Lens Attachment for above Stereo—provides 15X down to 6X with clear, extra large 1½" field at 6X.

Stock No. 30,276-W ----------$7.50

NEW, LOW-COST LAB PROJECTOR SHOWS EXPERIMENTS ON SCREEN!

New way to teach chemistry, biology. Project on-the-spot experiments, on screen or wall, with magnification, actually as they progress. Important phases, reactions may be observed by student group in revealing size—perfect vehicle for clear-cut instruction. Projector comes with a 3-element, 80mm focal length f/3.5 anastigmat lens and a fast 28mm focal length, 4-element f/1.2 lens for microslide projection use. Also you get prism erecting system; special elevated slide and specimen projection stage; standard 35mm, 2" x 2" slide carrier; 35mm strip film holder. Additional accessories available—water cooled stage; polarizing filters; petri dishes; miniature test tubes and holders; gas absorption apparatus, electrolytic cells and many others.

Stock No. 70,230-W ----------$45.00 Postpaid

NOTICE!

EDMUND IS HEADQUARTERS FOR MATH LEARNING AND TEACHING AIDS!

Play This New Game—

Math Magic . . .

The Fun-way to Math Skill!

Educator-approved! 3 fascinating games in one! Great fun for the whole family. Increases skill at addition, subtraction, multiplication, division. Includes Dial and Spinner, Numbered Cards, Plastic Tokens, etc.—also rules and directions.

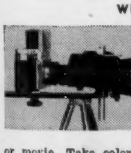
Stock No. 70,204-W ----------$3.00 Postpaid

D-STIX CONSTRUCTION KITS
For Scientists, Teachers

Scientists, teachers, planners—let D-STIX help you visualize and crystallize complex ideas. Colored wood sticks ¼" thick and "easy-on" rubber joints approx. 3/16" diam. fit together fast—help you work out molecular structures, geometric figures, structural members, shapes, models of scientific apparatus. Ideal for "3-dimensional thinking." instruction, demonstration. Durable kits. Money-back guarantee.

Stock No. 70,209-W (230 pcs) ----------$3.00
Stock No. 70,210-W (370 pcs) ----------$5.00
Stock No. 70,211-W (452 pcs) ----------$7.00

NEW BINOCULAR-TO-CAMERA HOLDER
Will Fit Any Camera



For Exciting Telephoto Pictures. Bring distant objects 7 times nearer with a 35mm camera, 7x50 binocular and our NEW BINOCULAR-TO-CAMERA HOLDER. Ideal for long-range shots of wild life, ships, people, vistas. Camera and binoculars attach easily. Use any binocular or monocular—any camera, still or movie. Take color or black and white. Attractive gray crinkle and bright chrome finish. 10" long. Full directions for taking telephotos included.

Stock No. 70,223-W ----------$11.50 Postpaid

Photographers! This is an actual photograph of the moon taken through our Astronomical Telescope by a 17-year student.

See the Stars, Moon, Planets Close Up!
3" ASTRONOMICAL REFLECTING TELESCOPE
60 to 180 Power. An unusual Buy! Famous Mt. Palomar Type

You'll see the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Star Clusters, Moons of Jupiter in detail. Galaxies! Equatorial mount with lock on both axes. Aluminized and over-coated 3" diameter high-speed f/10 mirror. Telescope comes equipped with a 60X eyepiece and a mounted Barlow Lens, giving you 60 to 180 power. An Optical Finder Telescope, always so essential, is also included. Sturdy, hardwood, portable tripod—**FREE with Scope:—Valuable STAR CHART plus 272 page "HANDBOOK OF HEAVENS" plus "HOW TO USE YOUR TELESCOPE" BOOK.**

Stock No. 85,050-W ----------$29.95 Postpaid

4¼" Reflecting Telescope—up to 255 Power
Stock No. 85-006-W ----------$74.50 F.O.B. Barrington, N.J.

NEW! CIRCULAR SLIDE RULE!

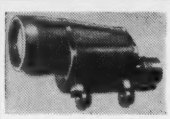
Pocket Size—Fast—Easy to Use! Be a Math Whiz! New Circular Slide Rule multiples, divides, figures fractions, percentages, squares, cubes, roots, proportions, circumferences, areas, retail prices, fuel consumption. Eliminates the confusions of ordinary slide-rules. Priced far lower. Faster, easier to learn and use. Constructed of 2 aluminum discs with plastic indicator. 3½" diameter. Directions included.

Stock No. 30,336-W ----------$4.95 Postpaid

Terrific Buy! American Made!
OPAQUE PROJECTOR

Projects illustrations up to 3" x 3½" and enlarges them to 4 ft. wide. No film or negatives needed. Projects charts, diagrams, pictures, photos, lettering in full color or black-and-white. Operates on 115 volt, A.C. current. 6-ft. extension cord and plug included. Operates on 60 watt bulb, not included. Size 12" x 8" x 4½" wide. Weight 1 lb., 2 oz. Plastic case with built-in handle.

Stock No. 70,199-W ----------$7.95 Postpaid



Take Telephoto Shots Thru

7 x 50 MONOCULAR

This is fine quality, American made instrument—war surplus! Actually ¼ of U.S. Govt. 7 x 50 Binocular. Used for general observation both day and night and to take fascinating telephoto shots with your camera. Brand new. $95 value. Due to Japanese competition we close these out at a bargain price. Directions and mounting hints included.

Stock No. 50,003-W ----------$15.00 Postpaid

Beginner's Lens Kits!

Fun for adults! Fun for children! Kits include plainly written, illustrated booklet showing how you can build lots of optical items.

Stock No. 2-W—10 Lenses ----------$1.00 Postpaid

GIANT MAGNETS!
Terrific Bargains!

War surplus — Alnico V type. Horseshoe shape. Tremendous lifting power. 5 lb. size. Dimensions: A—3¼"; B—2¾"; C—4 3/16"; D—1¼"; E—1¼"; F—2⅝". Strength is about 2,000 Gauss. Will lift over 125 lbs.

Stock No. 70,183-W ----------$8.50 Postpaid

15¾ lb. size. Approximately 5,000-6,000 Gauss rating. Will lift over 250 lbs.

Stock No. 85,088-W ----------$22.50 F.O.B. Shipping Wt. 22 lbs. Barrington, N.J.

"EASY-CARRY" SLIDE PROJECTOR

Ideal for travel or occasional use. PROJECT and SHOW 2x2 35mm slides or 35mm film strips, single or double frame. No cumbersome equipment to lug. 100-watt, 120-volt Projector folds to 2½" wide, 4½" high, 4½" long. Opens to 8" long. Wt. less than 3 lb. 3-element f/3.5 lens with 80mm focal length. Plastic leatherette carrying case. 6 ft. cord included.

Stock No. 70,232-W ----------$22.95 Postpaid

50-150-300 POWER MICROSCOPE

Amazing Value—Equal of a $75.00 instrument! 3 Achromatic Objective Lenses on Revolving Turret! Imported! Fine color-corrected, cemented achromatic lenses in the objectives give you far superior results to the single lenses found in the microscopes selling in this range. Results are worth the difference! Fine rack and pinion focusing.

Stock No. 70,008-W ----------$14.95 Pstpd.

MOUNTED 500 POWER OBJECTIVE

. . . Threaded for easy attachment on above microscope. Achromatic lenses for fine viewing. 3 mm. focal length.

Stock #30,197-W ----------$5.00 Pstpd.

NEW! STATIC ELECTRICITY GENERATOR
Educational and Lots of Fun

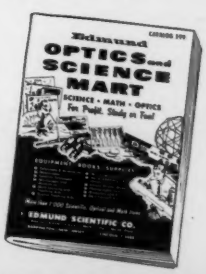
See a thrilling spark display as you set off a miniature bolt of lightning. Absolutely safe and harmless. Sturdily made—it stands 14" high. Turn the handle and two 9" plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark. Countless tricks and experiments. 24 page instruction booklet included.

Stock No. 70,070-W ----------$12.95 Postpaid

FREE CATALOG!

Optics for the Science Class!
Optics for the Space Era!

128 PAGES! OVER 1000 OPTICAL BUYS!

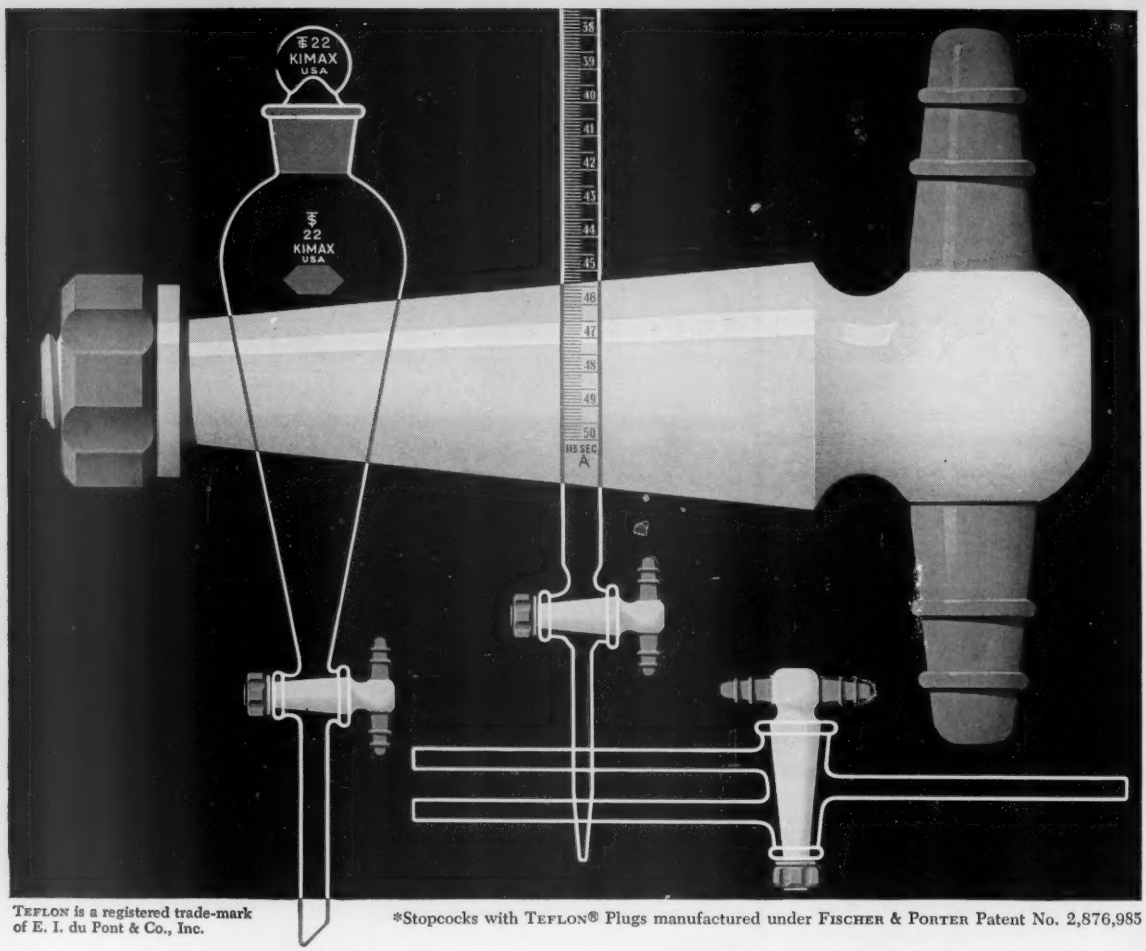


America's No. 1 optical source for experimentors, hobbyists. Huge selection of lenses, prisms, war surplus optical instruments, parts and accessories. Telescopes, microscopes, satellite scopes, binoculars, infrared sniperscope, etc. Low-cost Science and Math Learning and Teaching aids.

Request Catalog W.

ORDER BY STOCK NUMBER . . . SEND CHECK OR MONEY ORDER . . . SATISFACTION GUARANTEED!

EDMUND SCIENTIFIC CO. BARRINGTON, NEW JERSEY



TEFLON is a registered trade-mark of E. I. du Pont & Co., Inc.

*Stopcocks with TEFLON® Plugs manufactured under FISCHER & PORTER Patent No. 2,876,985

The stopcock plugs* are TEFLON®...

in this new line of KIMAX® Laboratory Glassware eliminating freezing, binding, grease contamination

KIMAX Laboratory Glassware now offers the convenience of TEFLON stopcock plugs . . .

No Binding—accomplished by exaggerated 1:5 taper of TEFLON Plugs in polished glass barrels.

No Freezing—because of extraordinary chemical inertness of TEFLON.

No Leaking—perfect fit of TEFLON Plug with the polished glass barrel.

No Contamination—self-lubricating . . . no grease needed with TEFLON stopcock plugs.

Easy Control—simple to adjust, control is easily maintained.

KIMAX Stopcocks with TEFLON Plugs are "interworkable" with other borosilicate glass of the same coefficient of expansion.

This new line of KIMAX apparatus with TEFLON Stopcock Plugs may be assorted with other Kimble laboratory glassware making possible larger quantity discounts. Your dealer will show you how you may realize more savings by specifying Kimble for all your laboratory glassware needs.

For further information, write Kimble Glass Company, a subsidiary of Owens-Illinois, Toledo 1, Ohio.

KIMBLE LABORATORY GLASSWARE
AN (I) PRODUCT

OWENS-ILLINOIS
GENERAL OFFICES • TOLEDO 1, OHIO

6 November 1959, Volume 130, Number 3384

SCIENCE

SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at National Publishing Company, Washington, D.C. The joint journal is published in the SCIENCE format. SCIENCE is indexed in the *Reader's Guide to Periodical Literature.*

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts and illustrations, see *Science* **125,** 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. If possible, furnish an address label from a recent issue. Give both old and new addresses, including zone numbers, if any.

Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢. Single copies, 35¢. Cable address: Advancesci, Washington.

Crowded Spectrum

Radioastronomers have hitherto devoted much effort to siting their radiotelescopes in locations as free as possible from man-made sources of radio noise; the best locations are those remote from transmitters of all kinds and protected by mountains from line-of-sight transmission from distant sources. Even this kind of siting is far from ideal. Radio waves are no respecters of international or spatial boundaries: weak signals of distant origin may bypass the mountains by reflection from the ionosphere. Satellites pose an additional hazard. They broadcast directly and also may reflect waves of earthly origin with enough intensity to interfere with reception by radiotelescopes. When communications satellites are put into orbit the threat will be increased.

Radioastronomers the world over are in general agreement about their needs. Because of the extraordinary sensitivity of their instruments and because weak signals can only be distinguished from background noise by repeated observation and averaging of results, they need certain bands of frequencies that are entirely free of man-made radio waves.

Two major difficulties stand in the way of satisfaction of these needs: in most advanced countries much of the radiospectrum is already allocated for governmental and private use, and international allocations of radio space are controlled by treaty. Thus, any freeing of parts of the spectrum for radioastronomy depends upon new internal and external agreements. It is in this context that the Administative Radio Conference of the International Telecommunication Union now meeting in Geneva is all-important for the future of radioastronomy. The 84 participating members are attempting to negotiate a new treaty for allocation of radio frequencies.

Radioastronomers in this country have been highly critical of the position of the U.S. delegation, which originally proposed to reserve only the hydrogen line from 1400 to 1427 megacycles per second and to work out other desirable allocations where practical. In anticipation of the current conference, the Federal Communications Commission several years ago made an inquiry on radioastronomy and elicited the opinions of individual radioastronomers. All agreed upon the importance of the hydrogen line, and all wanted other bands reserved, but they did not agree upon which ones. Many of those proposed cut into frequencies now in use by governmental and commercial broadcasters. These could be changed only upon the establishment of superior claims. Our delegation to the Geneva conference could not enter into a treaty that disregarded these domestic commitments. It could, however, get a foot in the door by agreeing to a "resolution" to allocate certain frequencies to radioastronomy. This would not have the force of a treaty, nor would it require Senate ratification, but it would permit gradual readjustment of the requirements and would amount to a statement of intent to support the needs of radioastronomy.

It is gratifying to report that, largely as a consequence of a meeting at the National Academy of Sciences–National Research Council on 16 October between radioastronomers and responsible government officials, including a representative of our delegation to Geneva, the U.S. position at the conference has become much more favorable to radioastronomy.

On 26 October the U.S. delegation, while continuing to ask for reservation of the hydrogen band for the exclusive use of radioastronomy, added 16 others for joint occupancy by present users and radioastronomy. This puts the U.S. closer to the position taken by the U.S.S.R., Great Britain, Belgium, the Netherlands, and others. It improves the outlook for gradual clearing of the desired bands, a step that will give radioastronomy a chance to continue its spectacular exploration of the cosmos.—G.DuS.

6 November 1959, Volume 130, Number 3384 SCIENCE

Digital Electronic Computers in Biomedical Science

Computers make solutions to complex biomedical problems feasible, but obstacles curb widespread use.

Robert S. Ledley

One of the most remarkable aspects of modern technology is the rapidity with which the field of high-speed digital electronic computers has developed. Although the first few computers were successfully operated barely 10 years ago, several thousands are in use today. Within that single decade this entirely new field has penetrated almost all phases of modern civilization, from nuclear energy production and missile design to the processing of bank checks and business inventory control. And in the research stages are already components that might make feasible computers many-fold more complex than present-day computers. It has been suggested that perhaps we are on the threshold of a new era in the history of mankind, arising from the utilization of electronic computing machines—likened to the industrial revolution, which was derived from the utilization of machines that automatically make commodities, thereby vastly increasing man's productive capabilities. Now we have available machines that vastly increase man's "thinking" capabilities, using "thinking" in the sense of planning, analyzing, computing, and controlling. We know the effects of this new era will be great, but we can now only speculate on the forms they will take. Not only will its influence be directly marked on the economic, political, and social aspects of our civilization, but it will have a tremendous effect in the physical and biomedical sciences as well.

Already there has been extensive use of computers in technology and the physical sciences. But in the biomedical sciences their use has barely begun. It is to be noted, however, that perhaps the greatest utilization of computers will be in biomedical applications. The problems that arise here characteristically involve large masses of data and many complicated interrelating factors, and it is just these types of problems for which computers are primarily suited. Also of great significance are the recent, dynamic changes taking place in the biomedical fields themselves: For example, biological processes are now being examined in terms of atomic structures, energy levels, binding forces, molecular configurations, and the kinetic and thermodynamic details of biochemical reactions. Increasing quantization, with concurrent emphasis on the biophysical and physiochemical bases of biological systems, is rapidly bringing a large portion of biomedical science to a point where complicated mathematical manipulations and mass data reduction and analysis are absolute prerequisites to further progress. The advantage in the use of computers for such purposes is not derived merely from the fact that the computer can perform complex mathematical and logical operations rapidly, but rather from the observation that the electronic computer makes feasible the solutions to problems that could not otherwise be approached. In this article the extensive applicability of computers in biomedical science is illustrated by means of specific examples, and then some of the important problems and obstacles arising in such utilization of computers are discussed (*1*).

I have in general confined my remarks to digital rather than analog computers, because it is digital computers that are capable of performing various complicated *logical* processes. This is not to imply that the analog computer does not have an important role in biomedical research; but the analog computer is usually of a more specific nature, not as capable of performing generalized computational procedures.

Analogy between hand computation and the functions performed by the parts of a digital computer. A general rule for evaluating the capabilities of a digital computer is: if the steps in the solution of a problem can be broken down into sequences of unambiguous instructions that conceptually could be performed by a very patient secretary who has no knowledge of the subject matter but who has infinite perseverance and can follow instructions precisely, never making an error, then the problem can be solved on a digital computer. This rule is an oversimplification only insofar as the necessary computation time on the computer and the cost of this time are also restrictions. It is, in fact, instructive to carry our analogy still further, describing the functions of the various parts of the computer (see Fig. 1). These are the input and output units, the memory, the control unit, and the arithmetic unit. The computer memory is analogous to the work sheet and instruction list of the hand computation: the memory stores the initial

The author is a part-time member of the staff of the National Academy of Sciences—National Research Council, Washington, D.C., where he is principal investigator of the Survey and Monograph on Electronic Computers in Biology and Medicine. He is on the faculty of the electrical engineering department of George Washington University, and he is a consultant on computers and digital systems.

data to be operated on, the intermediate results and the final results, and also the instructions themselves. The control unit interprets the instructions regarding the operation to be performed, the arguments to be operated upon, and the instruction to be chosen next; this is analogous to the computing secretary's mind. The actual operations indicated by the instructions are performed in the arithmetic unit, analogous to the secretary's desk calculator. The input and output units, which for the computer can be punched-paper-tape or card readers and punchers, or magnetic tape readers and writers, or character reading machines and high-speed printers, and so forth, are analogous to the secretary's pencils and graph paper.

Besides the great speed with which arithmetical and other operations can be performed (for example, modern computers can perform close to a half million additions per second) the computer derives its unique logical powers from its instruction-handling capabilities. These are basically of four types.

First, there is the chain instruction-sequencing capability of the computer to execute a list of instructions in sequence. For example, if

$$(ab + c)/d$$

is to be computed for given values of a, b, c, and d, the computer could be made to execute a sequence of instructions that formed the product $a \cdot b$, then added c to this result, and finally divided the sum by d.

Second, there is the decision capability of the computer to choose between alternative sequences of instructions for subsequent computations, depending upon the outcome of some previous computation. For example, suppose several different statistical procedures were to be applied to each set of input data, depending upon certain characteristics. In such a case the computer would be made to evaluate these characteristics for each set of data as it is received, and thence would choose the appropriate computational procedure to perform.

Third, there is the recursive computational capability of the computer to execute iteratively a sequence of instructions. For example, if a power series is being evaluated to a particular accuracy, each time a successive term of the series is computed its value is compared with the allowed error; if the term is smaller, the computer goes on to another part of the program, but if the term is larger, the computer adds it to the partial sum, adjusting certain constants, and repeats the general sequence of instructions to evaluate the next term.

Fourth, there is the instruction modification capability of the computer to change some of the instructions in its memory and then go on to compute with these modified instructions. In this way, for example, the computer itself can be made to write a sequence of instructions. This capability, and the other three as well, has implications more important and far-reaching than the mere ability to compute at high speed.

Examples of the Utilization of Computers

At present there are some hundreds of applications of computers being made in the biomedical sciences. Most of these are being made by relatively isolated research workers who are, with only few exceptions, people with extensive cross-disciplinary backgrounds. They include professors of anatomy who are also x-ray spectroscopists, physicians who were once electrical engineers, biophysicists and physiologists who originally were physicists, psychologists with extensive mathematical background, and others. As in any new field, the research workers involved are only recently becoming aware of each other's work. Media for the exchange of ideas in this field are not yet adequately developed; most of the communications among researchers in the field have been at several conferences and symposia. In general the biomedical utilization of computers is hampered by lack of available machine time, inadequate peripheral equipment, insufficient funds, and a lack of coding and programing assistance. On the other hand, those biomedical researchers who are using computers are to be congratulated for their success in bringing many difficult and diverse disciplines to bear on their problems, for their often ingenious uses of the computer, and for their persistent, resolute pioneering spirit in the face of severe obstacles.

It is of course impracticable to review here those hundreds of applications already in progress, or the many more that are being proposed. Hence I shall only mention applications sufficient, I hope, to indicate the immense potential of this powerful new tool. The illustrations are based on unpublished as well as published material, proposed as well as completed and in-progress applications (see the "Selected Bibliography" at the end of this article). It is most convenient to consider the applications in four basic (but inevitably overlapping) categories: (i) numerical solutions to (partial) differential equations of biology and medicine; (ii) simulations of biological systems or aspects thereof as entire entities; (iii) biomedical data processing and reduction; (iv) biomedical information retrieval systems.

Numerical solutions to differential equations. One method for studying a biological phenomenon is to make some hypotheses concerning its mechanism, write the corresponding (in general, partial) differential equations, and compare the solutions of the equations with experimental data. If the solutions do not agree with the data, the hypotheses are altered, and the process is repeated. This method of course has been used for centuries in the physical sciences. In many instances it is not too difficult to write partial differential equations to describe a complex phenomenon reasonably; however, more often than not it is found that such equations cannot be solved by conventional analytic methods. Yet, with the utilization of electronic computers they may frequently be solved numerically. Indeed, the numerical solution is often the most desirable, since it can be compared directly with the experimental data.

Computers are being used to assist in the complicated and extensive computations that are frequently involved in obtaining information about the precise atom-structure or the over-all size and shape of crystallizable molecules, from x-ray diffraction patterns. Various organic molecules have been and are being analyzed by this method, including the well-known cases of vitamin B_{12}, myoglobin, hemoglobin, lysozyme, and the hydroxyapatite of teeth and bone. These methods are also being applied to the analysis of the structures of amino acids and peptides, and the over-all shape of nucleic acids and other large molecules. For noncrystallizable substances, information about their structures can be obtained from scattered light interference patterns, osmotic pressure and viscosity measurements, and sedimentation rates. Here the computer could again significantly assist in the computations involved.

Another relatively active field in the use of computers is the study of differential equations relating to the mech-

anisms of biological systems. The famous Hodgkins-Huxley equations, and several variations thereof, have been analyzed with respect to the properties of excitable membranes. Besides the computations, well under way, concerning the nature of nerve-fiber conduction, other studies will apply these equations to muscle-fiber excitability. Other equations, relating to semipermeable membranes and the diffusion and motility of large molecules, could be solved numerically on the computer for complicated geometries and other specifications. This capability presents a further tool in the study of the nature of the physical phenomena involved in intracellular dynamics.

Complicated sets of interrelated differential rate-equations can in many cases be solved on the computer. Such computations have been applied to multiple-reaction-rate problems involved in the exploration of certain metabolic processes. Computations involving such sets of equations have been used to predict intermediate reactions from a knowledge of experimentally determined final reaction rates. Another important problem using rate-equations to which computers have been applied is that of tracing through the various organs and systems of the body the time course of injected radioactive substances, for diagnosis of metabolic disturbances. For example, if radioactive iodine is used for a test of hyperthyroidism, the amount of radioactive substance would be measured as a function of the time in such "compartments" as the blood iodide, the protein-bound iodine, the thyroid gland, the feces, and the excreted urine. From these data the appropriate fractional-turnover rate-equations are solved for the turnover-rate constants between compartments, these constants being the desired indices of disease. Facets of this problem are still being worked out, such as uniqueness of results, consistency of redundant information, statistical variation, and so forth. Radioactive-carbon-tagged chemicals can be used in this manner for pinpointing specific dysfunctions of the metabolic pathway, opening up new fields of research in computer-aided specific diagnostic analysis. Finally,

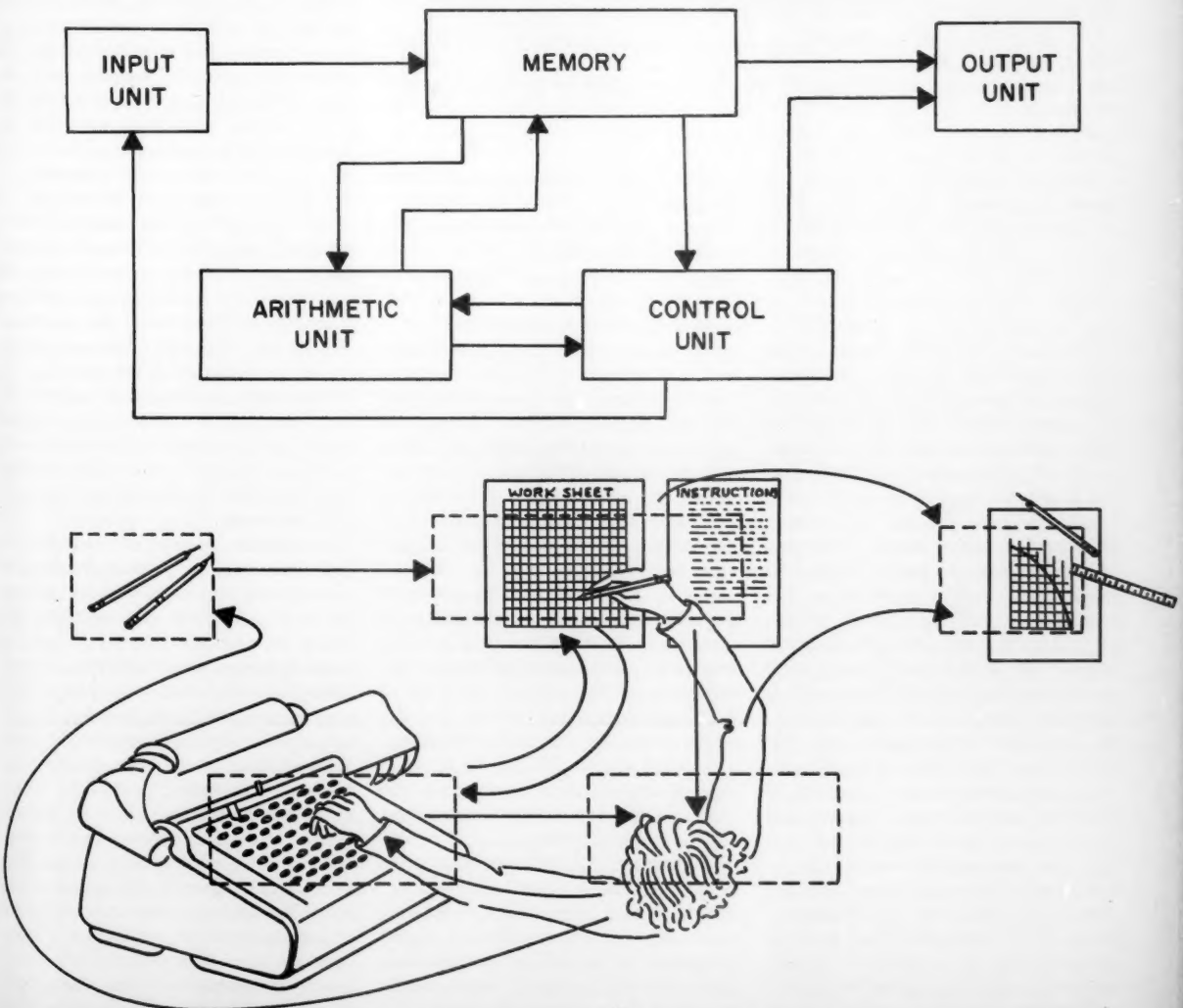


Fig. 1. Analogy between manual computing and an electronic digital computer. The arrows indicate the flow of information.

Fig. 2. Picture-reading machine for input to digital computer (developed at the National Bureau of Standards) showing detail of scanning phototube flanked by light sources that illuminate the picture bound around the rotating drum. [Courtesy National Bureau of Standards]

complicated rate-equations occur in many homeostatic mechanisms, such as in the regulation of the formation, maturation, and elimination of erythrocytes, lymphocytes, and granulocytes.

Other computer applications are associated with the solution of partial differential equations that attempt to describe the flow of blood in large arteries, such as the aorta. Numerical solutions to these equations can be compared with experimental results for verification of the hypotheses embodied in the equations. A study of mortality is being made with the use of stochastic differential equations, that is, differential equations with stochastic coefficients chosen from specified distributions. The solutions to such equations in general present severe analytical difficulties and can be approached only by means of direct computations with an electronic computer. One of the earliest biomedical computer applications was the evaluation of the forces applied to the teeth during mastication. The results of this study have an important application to the proper construction of full dentures and other prosthetic appliances, as well as to orthodontics. Many other examples, too numerous for description here, exist in such widespread fields as determination of radiation dosage, quantum mechanics applied to molecular metabolic reactions, analysis of circadian cycles, and so forth.

Simulation of biological systems. Complicated and highly involved phenomena, such as entire biological systems, can be analyzed by means of computer simulations. Usually a great deal is known about the local-component aspects of such a system; but a study of how these many complicated parts combine to make the whole has not heretofore been generally feasible because of the immense amount of calculation required. However, these calculations can frequently be accomplished if the functional equations of the component parts and their interaction rules are assembled on a digital computer. The purposes and uses of a computer simulation are to enable (i) the study of a complicated system as an integrated result of many individual, interacting component parts, (ii) the evaluation of the relative influence of each small component in relation to the whole system, (iii) the testing of hypotheses about a part of a system for consistency with known data about the whole system, and (iv) the designing and planning of future, more critical experiments concerning still unknown components of the system. Unfortunately, although many large-scale system simulations have been carried out on digital computers in the military and business fields, few if any have been accomplished in the biomedical field.

Many physical and chemical characteristics of biological phenomena evidently can be studied only by considering individual molecular reactions. Here, mathematical analysis based on large numbers of statistical aggregates of molecules does not suffice. An important method for studying such complicated phenomena is the so-called Monte Carlo simulation, which in most instances can be carried out only on an electronic computer. With Monte Carlo methods, the effect of individual molecular motion, collisons, chemical reactions, and interacting forces can be simulated according to some assumed model, and the over-all statistical responses of the system can be predicted, to be compared with experimental results. The initial state of the model is first described, including estimates of the sizes, shapes, initial positions, velocities, and orientations of each of the molecules of the system. Then a stepwise process for following the individual particles through increments of time is established that includes the molecular kinetics and possible chemical reactions. The "Monte Carlo" aspect of such a simulation enters as random numbers are successively chosen from appropriate distributions, for the determination of the initial conditions of each molecule and for other random processes that may enter into the dynamics of the system during the stepwise incremental time computations. The origin of the physical characteristics of colloids, jells, and other suspensions is being investigated in this manner. Certain enzyme systems, too, are being studied by this process. The method could also be applied to many aspects of cellular dynamics for a better understanding of the roles of various cytological structures.

In addition, Monte Carlo simulations have been applied to cell division problems in which the computed resting time between individual cell divisions depends on the selection of a random number from a given distribution function. The effect that varying this function has on the total number of cells obtained after a given period of time has been studied in connection with the growth of malignant tumors. Similarly the motion of sperm cells in electric fields was studied to determine whether a nonrandom drift actually occurs. The simulation of genetic changes can also be useful for evaluating rates involved in genetic dynamics. Analogously, much can be learned from Monte Carlo simulations of epidemics, where the spread of a disease from individual to individual is determined by laws with random

components. Some work has already been accomplished on computer simulations of self-organizing neural nets, in the investigation of learning, pattern recognition, and other phenomena of the brain. Here the organization of "connections" between *individual* neurons is simulated: The connections are made or broken according to certain general rules associated with simulated stimuli input to the neural net, and with certain random processes. The way in which the simulated neurons then *collectively* organize themselves is studied as the simulation progresses.

Biomedical data processing and reduction. There are a great many applications of computers in the straightforward statistical analysis of medical records, experimental results, and other data. Notable is the large variety and amount of psychological research being accomplished: the psychologists always seem to be among the first to take advantage of the computer in a newly established computing center. Computers are aiding the statistical evaluation of new drugs, correlation of disease with various possible etiologies, studies of the effectiveness of new cures and preventives, and so forth.

A different kind of data reduction problem is involved in connection with various continuous recordings obtained from living animals, such as electrocardiograms, electroencephalograms, gastroenterograms, and electromyograms. Projects concerned with the first of these are usually directed toward attempts to correlate the recordings with abnormalities and diseases. However, before a digital computer can be applied to the analysis of such recordings, the recordings must first be put into digital or numerical form. Only recently has an integrated program been established for the mass collection of electrocardiograms in such form. On the other hand, much work has been accomplished in applying the computer to the problems of electroencephalograms. Here the purposes of the analyses are to learn more about the brain mechanism as well as to correlate with diseases. The problems here, however, are more severe, since the recordings appear to have large random components. Auto- and cross-correlation techniques, averaging, and pattern-recognition methods have been applied, particularly with regard to auditory and other sensory studies. Digital computer application to the analysis of electroencephalographic recordings, from animal experiments on the mechanisms of the brain, are currently being initiated. Further modes of analysis, such as the use of stochastic differential equations, are being anticipated. Thorough evaluation of these data without the use of a computer would generally be infeasible.

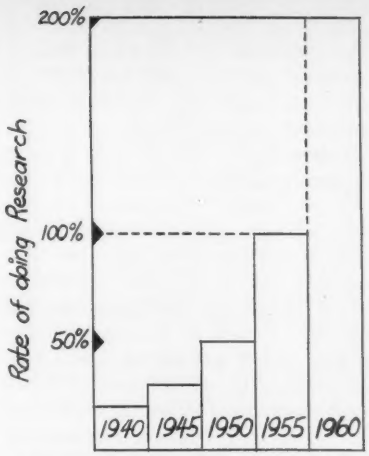


Fig. 3. Estimated rate of doing research. Indices used to measure this rate were estimates of research manpower employed, funds expended, and pages of published results. The data were extracted from J. A. Shannon and C. V. Kidd [*Science* **124**, 1185 (1956)], annual appropriations to NIH, *American Men of Science*, *Chemical Abstracts*, and from other sources.

An interesting possible application of computers is sequential microphotographic analysis. The purpose is to take full advantage of a relatively recent development in the collection of biological data, namely, the production of remarkable motion-picture photomicrograms of important biological processes such as capillary blood flow, motion of mitochondria in a cell, and so forth. A unique use of the digital computer for the analysis of these pictures arises in connection with the recent development of a picture-reading machine that can record in the memory of a computer a black and white version of an entire picture, as seen by a scanning photomultiplier tube (see Fig. 2). As an example, consider a motion picture taken of differentially stained nervous tissue through a microscope as the plane of focus is moved through the tissue section. By comparing successive frames of the movie, it may be possible to have the computer automatically trace thousands of neuron-array axon connections, a procedure that could not be feasibly accomplished manually. The process is similar to the automatic tracking of aircraft by computers, on successive sweeps of radar antennas. The same process can be applied for the detailed mapping of capillary beds, to obtain quantitative information on the physical relationships between the capillaries and the glomerulae of the kidney or the alveolae of the lung. Successive frames of films showing dynamic cellular processes can be analyzed by this method to obtain quantitative kinematic relationships, which can then be used to analyze the forces involved.

Information retrieval. The difficulties in sifting the past research results of others, and in keeping abreast of current research results, are rapidly increasing. The growing acuteness of this problem in the biomedical fields is due to the rapidly increasing research rate, which has more than doubled since 1950. In fact, the total of all medical research expenditures in the United States will probably have doubled again in the period from 1955 to 1960 (see Fig. 3). Recognition of these problems in other fields as well has stimulated much current work in various basic and applied aspects of information retrieval. Some of the basic work is concerned with the application of computer methods to automatic language translation, to automatic abstracting, to semantic problems as applied to retrieval, and so forth. Several commercial firms are presently working on specialized automatic information retrieval machines designed to retrieve information on a multidimensional or coordinate basis. Various ideas have been proposed for the utilization of such machines by research workers. One of these recommends that instead of being published in journals, research results might be transmitted to a central information center. Then when a researcher desires information on a particular subject, pertinent research results would be retrieved and reports sent to him. Since in this system research results now published in hundreds of different journals would all be filed together, and since the information center's retrieval computers would retrieve on a multidimensional or coordinate basis, the reference value of such a center would be far superior to that of present-day publication methods.

Another idea utilizes a method for obtaining multidimensional or coordinate retrieval in a bound-book form of bibliography. Such bibliographies of current periodical literature in specialized fields can be prepared rapidly, and printed out in the proper page formats, by electronic computers. Offset copies of the bibliography can then be distrib-

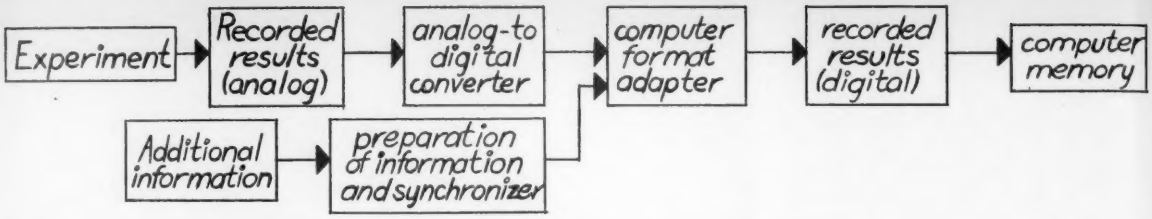


Fig. 4. Steps in data input to computer's memory.

uted to research workers in their laboratories for easy, rapid, and convenient reference. Since by this method the bibliographies would be relatively cheap to compile and print, new bibliographies including all current material could be made frequently; research workers would then throw away old bibliographies on receipt of new ones.

The great advances in medical knowledge of the past few years have not been matched with a parallel advance in making this knowledge available to the practicing physician. The information must be available in a retrievable form, for certainly a physician cannot be expected to read and remember the details of all current articles and reports with which he is confronted, on every specific disease and subject.

Thus there is also an urgent need for an information transfer system which would make *easily* accessible to the individual practicing physician the most current information or development on a disease or subject, at the *time* he needs it, at the *place* he needs it, and in a form he can use. Such a current information-transfer system could give the physician *instant reference*, in his office, to research results taken from articles published in hundreds of journals, or perhaps direct from research laboratories. Current advances in computer technology make such a plan entirely feasible. One suggestion, for example, is to use the telephone dial as the communications link between a retrieval computer and the physician. The physician could dial into the computer codes referring to diseases, drug actions, or other information desired, and would receive information by means of computer-operated talking machines, telephone-television, or other more advanced communication techniques presently available or being developed.

A national health computer network has been suggested as a means for accumulating and recalling desired aspects of individual total medical records, for assisting certain aspects of medical diagnosis, and for collecting and evaluating exceedingly important medical statistics as well as for greater public health control and for the medical information retrieval processes discussed above. For example, just the availability of the biochemical and physiological indices of an *individual's* normal state of health, which in general deviate from the *population* norms now used, may serve as an invaluable tool in instituting preventive measures *before* diseases occur, as well as in diagnosing disease states. The feasibility of such a system from a computer technology point of view is unquestioned, since there are already computers that carry out such closely related processes as making nationwide airline and hotel reservations, recording, updating, and tallying bank accounts and other financial records, controlling large-scale defense installations, and so forth. However, such a health computer network is probably still a concept of the far-distant future, for much research and planning is evidently still necessary on almost every phase of the problem.

Problems and Obstacles

Cross-disciplinary training. Although the potentialities of computers in the biomedical sciences are very great, there are several formidable problems that occur at present in connection with their more widespread use in this field. First is the gap that frequently exists between the knowledge and training of the biomedical research worker and the knowledge necessary to use the computer. There is great need for cross-disciplinary training in this area to give biologists a more thorough knowledge of those subjects required for the utilization of a computer and also to give those skilled in computer engineering and use a knowledge of the basic biological problems to which computers may be applied. In general the most fruitful applications of computers to biological problems will probably arise from the biologist who has gained the knowledge prerequisite to using the computer—for it is, of course, still primarily knowledge of the biomedical problems that must be used to evalute and judge which problems can benefit most from application of computers. However, the engineer or mathematician who can understand the significance of the various biological research developments and who knows the language of biology and medicine can be of invaluable assistance. I strongly believe that "team" approaches, where the biologist has no computer-oriented training and the engineer or programer has no biological training, are foredoomed to failure. For the full significance of the extensively detailed and often subtle aspects of the use of computers in biomedical science can be understood only by those well grounded in both fields.

From the point of view of the biomedical scientist, the main subjects in this cross-disciplinary gap lie first in the specific techniques of the actual utilization of the computer, that is, coding and programing, and second, in the mathematical methods and techniques that form the analytical basis for the statement of the problem and its preparation in a form appropriate for the use of a computer. For example, studies in the following subjects could help to bridge the gap: (i) basic coding and programing of digital computers, including the use of the automatic programing aids currently being extensively developed; (ii) sampling methods and techniques for appropriately preparing (that is, digitalizing and interpreting) experimentally generated data for use on the digital computer; (iii) minimum basic electronics and knowledge of the problems involved in analog-to-digital and digital-to-analog conversion; (iv) the origins of numbers, the meaning of significant figures and their relation to relative errors, and the effect on significance of arithmetic operations; (v) the meaning of the function concept, the classification of functions by analytic properties, the approximation of functions by series and otherwise, and numerical techniques

for function evaluation; (vi) the meaning and utilization of differential equations, and techniques for their numerical evaluation; (vii) the elements of modern algebra, including Boolean algebra and related subjects; (viii) basic probability and statistics; (ix) critical analysis of the techniques of the scientific method, such as model building, testing of hypotheses, the problems of overdetermined and underdetermined systems, and so forth. This may appear as a severe and formidable course of study, but the technical problems that frequently arise in these uses of computers can be crucial. The very nature of digital computers makes stringent demands on those who wish to utilize them, almost independently of the particular application.

Necessary peripheral equipment. The second important problem associated with the use of computers in the biomedical sciences is the frequent necessity for understanding and handling rather elaborate electronic peripheral equipment. The biomedical researcher must in general work closely with experimental data and results, which he frequently generates in large amounts (in contradistinction to the physicist, who can often approach his field from an almost purely theoretical standpoint). Before these data can be utilized by the computer, they must first be converted into a form appropriate for input to the computer's memory. The electronic equipment that performs this conversion, known as peripheral equipment, besides being costly is frequently not available commercially. And even if it is commercially available, more likely than not modifications are necessary to make it compatible with the experimental setup. Thus specialized electronic equipment, often uniquely designed for the particular experimental setup involved, must frequently be constructed.

The most common problem associated with peripheral equipment is concerned with data that are generated in analog form. The digital computer requires that the analog data be periodically sampled, and converted into numerical form, by means of an analog-to-digital converter. Here problems of the data-sampling rate and also of the number of significant figures in the converted result must be dealt with. The analog data often are recorded first, to be later digitalized and read into the computer (see Fig. 4). The analog re-

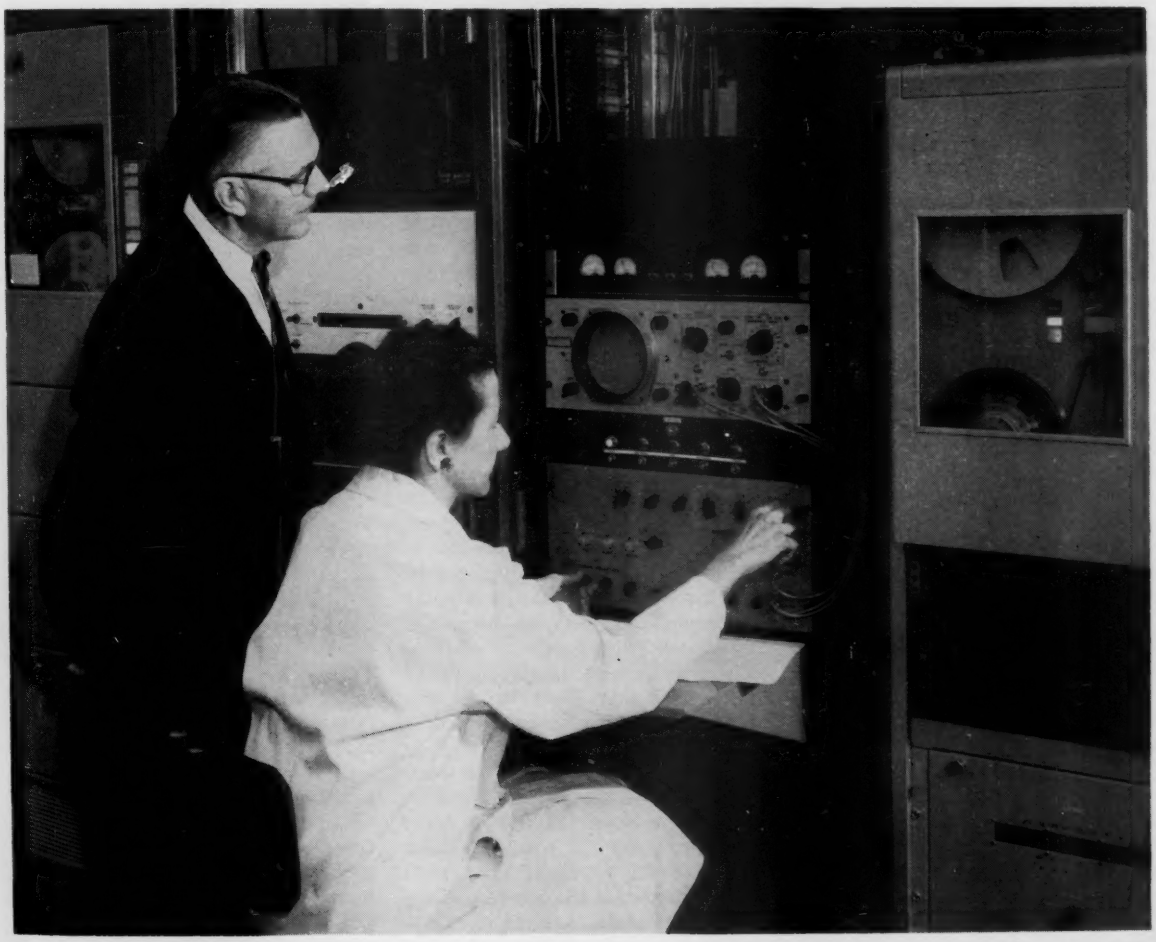


Fig. 5. Equipment for preparing electrocardiograph records for input to a digital computer, developed for the Veterans Administration at the National Bureau of Standards, showing the magnetic tape recorder containing the analog electrocardiograph records, the analog-to-digital converter, the format adapter and synchronizer for the insertion of additional information, and the magnetic tape recorder containing the digital data. [Courtesy National Bureau of Standards]

cordings can be made on magnetic tapes, by oscillographic recording, or by other means. However, the converted or digitalized data are still not ready to be read into the computer. First the numerical data must be organized into a format appropriately adapted to the particular computer used. This requires another piece of electronic equipment. Frequently additional information describing the data (for example, date, run number, specifications of the experiment) is incorporated at this time into the already converted data. Again it is sometimes convenient to record the processed information, usually on magnetic tape; this time, however, the magnetic tape can be used as direct input to the computer (see Fig. 5). Of course, not all these steps are always necessary: for example, when the computer is used in a real-time experiment—that is, when the output of the computer is to help control the experiment—it is usually desirable to transmit the generated experimental data directly through the analog-to-digital converter and format adapter into the computer, with no intermediate recording. Different kinds of analog-to-digital converters are required, depending on the forms of the analog information. For example, the most commonly used converters accept analog input as a voltage magnitude; a picture-reading machine converts black and white areas into digital form; various converters are available for mechanical analog-to-digital conversion, and so forth.

Other types of peripheral equipment frequently required are those concerned with the output of the computer, for example, special printers, pictorial displays, or digital-to-analog-output voltage converters. Still other functions performed by peripheral equipment are concerned with the transmission of digital data between computers, or between the computer and some distant location such as a hospital or a research center.

Technical communication and the exchange of ideas. Research has two aspects which seem opposed: on one hand it is very personal and private in the sense of individual creativity, while on the other hand it is gregarious, its life blood and very existence based on the extensive exchange of ideas. So it is with computer programing. In fact, it is reasonable to say that a good portion of the ingenuity and creativity of the biomedical researcher will be embodied in his coding. The accuracy, flexibility, and intrinsic structure of the computer program are of central importance in the utilization of computers. A major portion of the time and energy of a biomedical researcher using computers, and of the money he spends, is consumed in the process of setting up and evaluating his program. Therefore, he will have a strong desire to exchange ideas, and to communicate to the scientific world some of the technical advances he has made in the programing itself. However, at the present time this is indeed difficult to accomplish, for existing biological journals generally have not yet recognized the importance of the contribution of such technical communications. There are many reasons for this, one of which is the unique technical language that necessarily appears in discussions of computer programs. There are two major journals that might provide outlets for this information—the *IRE Transactions on Medical Electronics* and the *Journal of the Association for Computing Machinery*—although at present several problems are involved. The *IRE Transactions* covers the much broader field of medical electronics, and it may be questionable whether the majority of its readers are interested in coding and programing details, while the ACM journal has not itself been completely successful as an outlet for computer programs, even in fields other than biomedical science. Hence there is a need for a suitable medium to enable the exchange of ideas on the use of computers in biomedical science.

Costs and availability of computers. Another important problem to be faced in the utilization of computers in biomedical science is the high costs, incurred directly in computer usage and in the procurement and maintenance of peripheral equipment. At the present time this is coupled with the difficulty of obtaining computer time, because of the generally higher priority given to physical and engineering problems and the frequent unavailability to the biomedical researcher of necessary peripheral equipment. The cost of time on a large-scale, high-speed digital computer generally runs from $200 to $300 and more per hour. The problem is not one of reducing this cost, but rather one of coming to the full realization that this is part of the cost of utilizing computers. Again, the usually substantial costs incurred in procuring or constructing, and maintaining, peripheral equipment is characteristic of the utilization of electronic equipment, no matter what the field of application. The major problem facing many biomedical researchers in this regard is that until recently expenditures of such large amounts were not customary. The average biomedical research grant is still in the neighborhood of $15,000 per year. Thus the biomedical researcher who finds that just a part of the peripheral equipment necessary to use computers can start with costs of $15,000 or more, may understandably be reluctant to plan for the utilization of computers.

Another closely related factor is that much biomedical research is now oriented about the individual researcher: he carries through almost all phases of the research himself, frequently with little or no assistance. The number of man-hours required to construct a complicated computer program is often much too large for any single individual to accomplish alone, in any reasonable time. Thus in many instances biological scientists may find orientation toward individual research incompatible with the use of computers. I do not intend to give the impression that all computer utilization will have this characteristic, for this is far from true. But there will arise a large number of cases where the staff approach, involving the partitioning of the problem into smaller parts among the members of an integrated group, becomes an absolute necessity. This again increases the magnitude of the costs that will be incurred in research projects. From this point of view projects utilizing computers in biomedical science will frequently become more costly than heretofore. But we cannot neglect the vastly increased capabilities such computer usage presents for the exploration of the complicated and intricate biophysical and physicochemical basis of biological systems.

Conclusions

The use of computers in biomedical science vastly increases the researcher's capabilities in approaching the exceedingly complicated and extensive computations so frequently required for investigation of the more modern quantitative and mathematical biochemical and biophysical concepts. The computer makes feasible approaches to problems that could not otherwise be solved; it opens up entirely new methods of biomedical investigation; it holds promise for assisting in the more efficient utilization of research results. Significant ap-

plications of computers are found in almost every aspect of biomedical research endeavors. Although there presently exists great interest in the use of computers among biomedical research workers, we are only on the threshold of understanding their full potential capabilities. However, many severe obstacles and problems must be overcome before their full utilization can be realized. Among these are the urgent needs for personnel trained in cross-discipline fields, for more extensive exchange and communication of technical scientific information in the field, and for a thorough appreciation of the generally larger resources and efforts that must frequently be associated with such use of computers.

Biomedical research workers should be encouraged to explore the extensive research opportunities offered by the utilization of computers. Toward this end the National Academy of Sciences–National Research Council is sponsoring the preparation of a survey and monograph on the use of computers in biomedical research. This project is supported by the U.S. Air Force Air Research and Development Command, and the National Institutes of Health. The survey will include past, present, and proposed applications of computers to biology and medicine, and is designed to stimulate ideas and methods for tackling various problems. The monograph, planned to appear in the summer of 1960, is designed to function as a semi-handbook, an attempt to assist in bridging the technical gap that frequently exists between the biological researcher's training and experience and the knowledge he needs in order to use computers. It is hoped that this effort will play at least a small role in encouraging the more complete understanding and fuller realization of the tremendous potentials of computers in biomedical science.

Note

1. I wish to express appreciation to the many people throughout the country who generously discussed with me many research ideas and projects concerning the use of computers in the biomedical sciences. Special thanks are due to Louis S. Rotolo, James Bruce Wilson, and Catherine Deininger for assisting me in this study.

Selected Bibliography

The following is a selected list of miscellaneous references for biomedical computer applications. Some general conference and book references discussing problems that may represent potential applications are also included.

Abstracts of the Biophysical Society Meeting, Cambridge, Mass., 5–7 Feb. 1958.

Abstracts and Proceedings of the 2nd International Conference on Medical Electronics, Paris, June 1959.

J. S. Barlow, "Autocorrelation and crosscorrelation analysis in electroencephalography," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.

M. Berman and R. L. Schoenfeld, "Information content of tracer data with respect to steady-state systems," in *Symposium on Information Theory in Biology* (Pergamon, New York, 1958).

———, "Invariants in experimental data on linear kinetics and the formulation of models," *J. Appl. Phys.* **27**, No. 11, 1361 (1956).

Bibliography on the 11th Annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.

A BIZMAC Program for Medical Data Processing (Radio Corporation of America, New York, 1957).

R. C. Bostrom, *The Cytoanalyzer 400* (Airborne Instruments Laboratory, Mineola, N.Y., 1959).

M. A. B. Brazier and J. S. Barlow, "Some applications of correlation analysis to clinical problems in electroencephalography," *Electroencephalog. and Clin. Neurophysiol.* **8** (1956).

H. E. Burke, "A survey of analog-to-digital converters," *Proc. I.R.E.* **41**, 1455 (1953).

R. A. Carpenter, C. C. Bolze, L. D. Findley, "A system for the correlation of physical properties and structural characteristics of chemical compounds with their commercial uses," *Am. Document.* **10**, No. 2, 138 (1959).

V. S. Carson, "Rapid automatic digitalization and sorting of random graphical data," *I.R.E. Trans. on Instrumentation* **PGI-5**, 113 (1956).

B. Chance, G. R. Williams, W. F. Holmes, J. Higgins, "Respiratory enzymes in oxidative phosphorylation: V. A. mechanism for oxidative phosphorylation," *J. Biol. Chem.* **217**, 217 (1955).

W. A. Clark and B. G. Farley, "Generalization of pattern recognition in a self-organizing system," *Proc. Western Joint Computer Conf.*, Los Angeles, Mar. 1955, pp. 86–91.

K. S. Cole, H. A. Antosiewicz, P. Rabinowitz, "Automatic computation of nerve excitation," *J. Soc. Ind. Appl. Math.* **3**, No. 3, 153 (1955); "Correction," *ibid.* **6**, No. 2, 196 (1958).

Communications Biophysics Group of the Research Laboratory of Electronics and W. M. Siebert, "Processing neuroelectric data," *Tech. Rept. No. 351* (Technology Press, Cambridge, Mass., 7 July 1959).

P. Elias and W. A. Rosenblith, "The use and misuse of digital models in the study of the nervous system," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.

B. G. Farley and W. A. Clark, "Simulation of self-organizing systems by digital computer," *Trans. I.R.E. Professional Group on Information Theory* (Sept. 1954).

B. G. Farley, L. S. Frishkopf, W. A. Clark, Jr., J. T. Gilmore, Jr., "Computer techniques for the study of patterns in the electroencephalogram," M.I.T. Research Laboratory of Electronics Tech. Rep. No. 337 (6 Nov. 1957).

B. G. Farley, L. S. Frishkopf, M. Freeman, C. Molnar, T. Weiss, "A summary description of EEG data with the aid of a digital computer," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19-21 Nov. 1958.

J. T. Farrar, "Digital computer diagnosis of gastrointestinal disorders from complex intraluminal pressure record," Conference on Diagnostic Data Processing, Rockefeller Institute, New York, 14 Jan. 1959.

D. Garfinkel, J. J. Higgins, J. D. Rutledge, "A Univac program for representing the kinetic behavior of chemical and biological systems," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.

M. M. Gertler, M. A. Woodbury, L. G. Gottsch, P. D. White, H. A. Rusk, "The candidate for coronary heart diseases," *J. Am. Med. Assoc.* **170**, 149 (1959).

"Giant brain to keep medical hospital records," *J. Franklin Inst.* **263**, 91 (1957).

A. K. Hawkes, "A technique for digital computer analysis of electrocardiograms," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.

R. L. Hayne and F. Turim, "Machine retrieval of pharmacologic data," *Advances in Document. and Library Sci.* **2**, (1957).

"High-speed computer to analyze human heartbeat," *Natl. Bur. Standards (U.S.) Tech. News Bull.* (Sept. 1959).

J. G. Hoffman, N. Metropolis, V. Gardiner, "Digital computer studies of cell multiplication by Monte Carlo methods," *J. Natl. Cancer Inst.* **17**, 175 (1956).

"Homeostatic mechanisms," Report of Symposium, No. 10, Brookhaven National Laboratory, Upton, N.Y., 12–14 June 1957.

G. W. Jackson, "Telephone electrocardiograph: the practical application of an ingenious device," *J. Kansas Med. Soc.* **57**, 4 (1956).

G. Karreman, I. Isenberg, A. Szent-Gyorgyi, "On the mechanism of action of chlorpromazine," *Science*, in press.

R. A. Kirsch, L. Cahn, C. Ray, G. H. Urban, "Experiments in processing pictorial information with a digital computer," *Proc. Eastern Joint Computer Conf.*, Washington, D.C., Dec. 1957.

G. G. Knickerbocker and G. N. Webb, "Patient data systems for hospitals," presented at the IRE National Convention, Medical Electronics Session, New York, 1958.

J. Kraut, "The shape of the chymotrypsinogen molecule from x-ray diffraction," *Biochim. et Biophys. Acta* **30**, 265 (1958).

R. S. Ledley, "Digital computational methods in symbolic logic with examples in biochemistry," *Proc. Natl. Acad. Sci. U.S.* **41**, No. 7 (1955).

———, *Digital Computer and Control Engineering* (McGraw-Hill, New York, in press).

———, "Logical aid to systematic medical diagnosis," *J. Operations Research Soc. Am.* **3**, No. 3 (1955), abstr.

———, "A new method of determining the functional forces applied to prosthetic appliances and their supporting tissues," *J. Prosthetic Dentistry* **5**, 546 (1955).

———, "The relation of occlusal surfaces to the stability of artificial dentures, *J. Am. Dental Assoc.* **48**, 508 (1954).

———, "Tabledex: A new coordinate indexing method for bound book form bibliographies," *Preprints of Papers for the International Conference on Scientific Information, Washington, D.C., 16–21 Nov. 1958*, pp. 395-417.

——— and L. B. Lusted, "Reasoning foundations of medical diagnosis," *Science* **130**, 9 (1959).

———, "The use of electronic computers to aid medical diagnosis," *Proc. IRE (Inst. Radio Engrs.)*, in press.

C. G. Lewallen, M. Berman, J. E. Rall, "Studies of iodoalbumin metabolism. I. A mathematical approach to the kinetics," *J. Clin. Invest.* **38**, 66 (1959).

M. Lipkin and J. D. Hardy, "Mechanical correlation of data in differential diagnosis of hematological diseases," *J. Am. Med. Assoc.* **166**, No. 2 (1958).

H. P. Luhn, "The automatic creation of literature abstracts," *IBM J. Research and Development* **2**, No. 2 (1958).

M. A. McLannan and E. G. Correll, "Instrumentation for a periodic analysis of the EEG," *Proc. IRE Conf.*, Houston, Tex., 1957.

H. A. Meyer, *Symposium on Monte Carlo Methods* (Wiley, New York, 1956).

R. Moore, R. H. Thompson, E. R. Buskirk, G. D. Whedon, "A proposed data-handling system for human metabolic studies," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.

J. L. Oncley, Ed., "Biophysical science. A study program," *Revs. Modern Phys.* **31**, No. 1 (1959); **31**, No. 2 (1959).

E. G. Pattishall, "The application of computer techniques to medical research," Report of Los Angeles Conference, contract AF 18 (600)-118, Oct. 1957.

L. Pauling and R. B. Corey, "The configuration of polypeptide chains in proteins," *Fortschr. Chem. org. Naturstoffe* **11**, 181 (1954).

H. V. Pipberger and E. D. Freis, "A project of the U.S. Veterans Administration for the electronic computation of electrocardiographic data," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.

C. S. Pittendrigh, "The oscillatory nature of physiological processes," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.

A. S. Posner, A. Perloff, A. F. Diorio, "Refinement of the hydroxyapatite structure," *Acta Cryst.* **11**, 308 (1958).

Proceedings of the IBM Medical Symposium, Poughkeepsie, N.Y., 15–17 June 1959, in preparation.
Proceedings of the Rockefeller Institute Conference on Diagnostic Data Processing, New York, 14 Jan. 1959, in preparation.
B. Rao, R. Allard, O. H. Schmitt, "An electronic computer program for calculating figures of merit and orthogonalization constants of electrocardiographic lead systems from transfer impedance data," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.
L. C. Ray and R. A. Kirsch, "Finding chemical records by digital computers," *Science* **126**, 814 (1957).
R. Robbins and K. C. Tsien, "Calculation of x-ray dose distribution by a digital computer," USPHS grant C-2483(c) progress report, 1 May 1956 to 30 April 1957.
Rochester, Holland, Habit, and Duda, "Tests on a cell assembly theory of the action of the brain, using a large digital computer," *IRE Trans. on Information Theory* (1956), pp. 80-93.
H. E. Rockwell, R. L. Hayne, E. Garfield, "A unique system for rapid access to large volumes of pharmacological data," *Federation Proc.* **16**, 726 (1957).
M. Rogoff and T. Gallagher, "Electronics in biochemical spectroscopy," presented at the IRE National Convention, Medical Electronics Session, New York, 1958.
F. Rosenblatt, "Perceptron simulation experiments," Cornell Aeronautical Laboratory, Rept. No. VG-1196-G-3, contract No. Nonr-2381(00), June 1959.
O. H. Schmitt, "Biological transducers and coding," *Study Program in Biophysical Science* (Wiley, New York, 1959).
J. A. Shannon, "Hearings before a Subcommittee of the Committee on Government Operations, U.S. Senate on S. 3126 and S. 4036," 85th Congress, pt. 2, 25 and 26 June 1958, pp. 492–497.
L. K. Steinrauf, J. Peterson, L. H. Jensen, "The crystal structure of *l*-cystine hydrochloride, *J. Am. Chem. Soc.* **80**, 3835 (1958).
"Summaries of current work in the division of biological and medical research," Argonne National Laboratory, Chicago, 1 May 1958.
A. K. Susskind, Ed., *Notes on Analog-digital Conversion Techniques* (Technology Press, Boston, 1957).
A. K. Susskind, "Approaches to design problems in conversion equipment," *Proc. Western Joint Computer Conf.*, Los Angeles, Feb. 1954, pp. 105–112.
S. A. Talbot, "Computers applied to ballistocardiography," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.
T. T. Tanimoto, *An Elementary Mathematical Theory of Classification and Prediction* (International Business Machines Corp., New York, 17 Nov. 1958).
J. W. Trank, "A statistical study of the effects of electric fields on the movements of mammalian sperm cells," presented at the 11th annual Conference on Electrical Techniques in Medicine and Biology, Minneapolis, Minn., 19–21 Nov. 1958.
L. Taback, E. Marden, H. L. Mason, H. V. Pipberger, "Digital recording of electrocardiographic data for analysis by a digital computer," *IRE Trans. Med. Electronics*, Sept. 1959.
J. Von Neumann, *The Computer and the Brain* (Yale Univ. Press, New Haven, 1958).
H. Weinrauch and A. W. Hetherington, "Computers in medicine and surgery," *J. Am. Med. Assoc.* **169**, 240 (1959).
H. Weinrauch and E. Pattishall, "Air Force and application of computers to medicine and biology," *Military Med.* **122**, 178 (1958).
R. J. Williams, *Biochemical Individuality* (Wiley, New York, 1956).
C. F. Wrigley, "Electronic computers and psychological research," *Am. Psychologist* **12**, 501 (1957).
———, "Use of electronic computers in psychology," *Proc. Electronic Business Systems Conf.* (1956).

Further Evidence of Vegetation on Mars

The presence of large organic molecules is indicated by recent infrared-spectroscopic tests.

William M. Sinton

There has long been evidence pointing to the presence of vegetation on Mars. Photographs taken by E. C. Slipher at Lowell Observatory for decades have shown a seasonal variation in the intensity of the dark regions. Every spring and summer, coinciding with the melting of the ice caps, a wave of darkening spreads from the polar regions toward the equator (*1*). In addition to the seasonal variation there have been nonsystematic changes: areas that were never dark have become dark, and a few dark areas have become light and have blended into the desert regions. A striking case of the appearance of a dark region occurred in 1954, when an area of 580,000 square miles at longitude 240° and latitude 20° was newly dark (*2*). The region in which it is situated has, however, been undergoing development for many years.

Some visual observers have often reported the dark regions as green or bluish, while others have found them neutral in color. Spectroscopic tests have also failed to find them green. The green color that is often seen may be only a complementary hue produced by the bright orange colors of the deserts.

Until recently there has not been a successful direct test for the presence of plants. Tests for the presence of chlorophyll have all been negative (*3; 4*, p. 362). These tests, which sought to find the high reflectivity characteristic of terrestrial plants in the near infrared, do not necessarily exclude chlorophyll. They can be explained if supposed Martian plants possess a pigment that absorbs the near infrared.

Using the 61-inch telescope of the Harvard College Observatory during the 1956 opposition, I made a new test for the presence of organic molecules on Mars (*5*). Organic molecules possess strong absorption bands at 3.5 μ as a result of the resonance of their carbon-hydrogen bonds. It was found that in the plants tested this band was double, most likely as a result of interaction between a pair of hydrogen atoms attached to the same carbon atom, as occurs in paraffin molecules.

The results of the 1956 observations indicated the presence of the band in the light reflected from Mars, but they left some doubt about the reality of the absorption. Furthermore, the regions of Mars which produced the absorption were not ascertained in this work. At the 1958 opposition the test was made again with improved equipment, and the reality and distribution of the band were established.

Instrumentation

As in 1956 the infrared from Mars was analyzed spectrally with a monochromator. A great improvement in sensitivity was obtained with a new liquid-nitrogen-cooled lead sulfide detector that was custom made by Infrared Industries, Inc. A further improvement was obtained by alternating the dispersed radiation from Mars between two separate detecting areas incorpo-

The author is a member of the staff of Lowell Observatory, Flagstaff, Ariz.

rated within this cell. The alternation was produced by moving the image of Mars from one to another of two apertures at the entrance slit of the monochromator. Moreover, the loss of light that aberrations produced in the condensing optical system used in 1956 was eliminated by use of a better condenser.

Through the courtesy of the Mount Wilson and Palomar Observatories, the 200-inch Hale telescope was made available during morning twilight hours for 2 weeks near new moon in October. The coudé focus was employed because its use would cause a minimum of interference to the scheduled observer at the prime focus. Conversion of the telescope from prime focus to coudé may be made in 10 minutes. With these technical improvements (*6*) investigations of different areas of the disk were made with approximately 10 times the sensitivity achieved in 1956.

Solar spectra were obtained in the afternoons with the equipment moved outside by the west door of the dome. A scattering plate of ground aluminum was placed in sunlight with its surface perpendicular to the earth's axis. It was viewed by the monochromator from a point toward the south pole. With this arrangement no tracking mechanism was required. The scattering properties of the plate have been tested to make certain that no distortions were introduced into the solar spectrum.

Observations

Spectra were obtained on 13 mornings in the period 7 to 21 October and also during the first half of the night of the 21st, when strong moonlight prevented observations of nebulae with the telescope.

For the most part two combinations of slit widths and apertures were employed. In one set a pair of apertures 1 mm in diameter was placed in front of the entrance slit to restrict observation to a part of the 2-mm image of Mars. The width of the exit slit of the monochromator was 2 mm and gave a band pass of 0.11 μ. For most of the other observations no aperture other than the 1 mm width of the entrance slit limited the observed part of Mars. The exit slit was also 1 mm, giving a band pass of 0.056 μ at the expense of loss of resolution on the disk.

Thirty-two spectra were obtained of

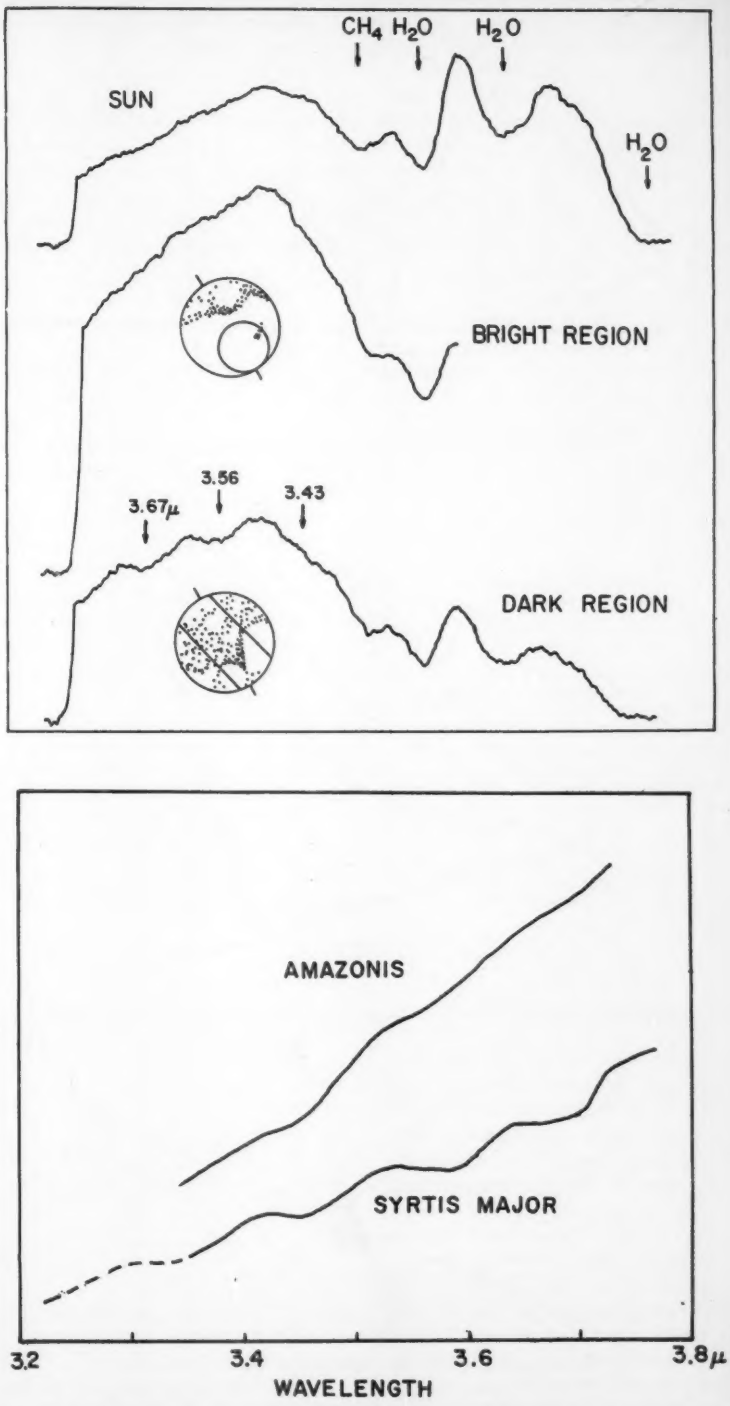
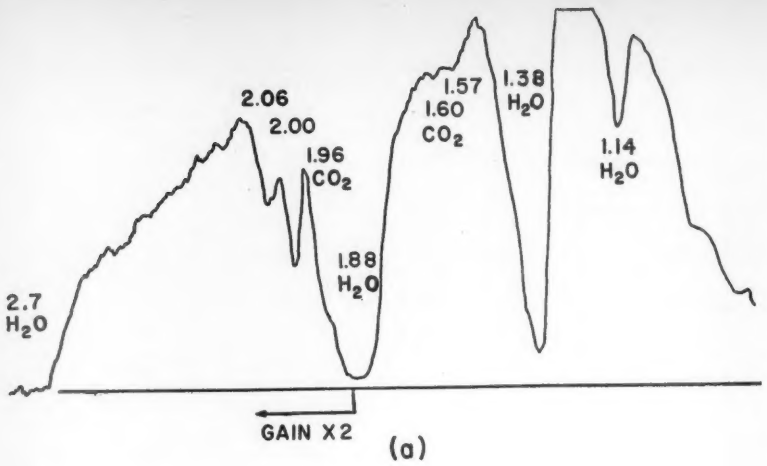
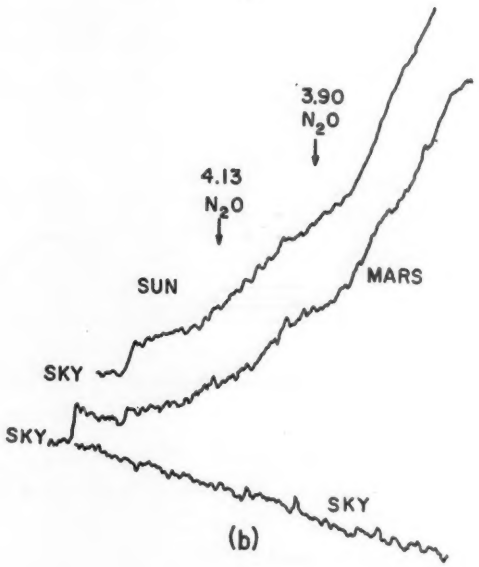


Fig. 1 (Top). Infrared spectra of Mars and the sun. The upper curve shows the spectrum of the sun with absorptions produced by water and methane in the earth's atmosphere. The middle curve is the spectrum of Amazonis, the desert region within the circle in the sketch. The bottom curve shows the spectrum of a strip across Mars as shown in the sketch and includes Syrtis Major. The last spectrum shows the absorptions supposedly due to organic molecules. Fig. 2 (Bottom). The spectra of Amazonis and Syrtis Major after division by the solar spectrum. The dashed portion of the curve is the region through strong methane and water-vapor absorption. The variations are not believed to be significant.





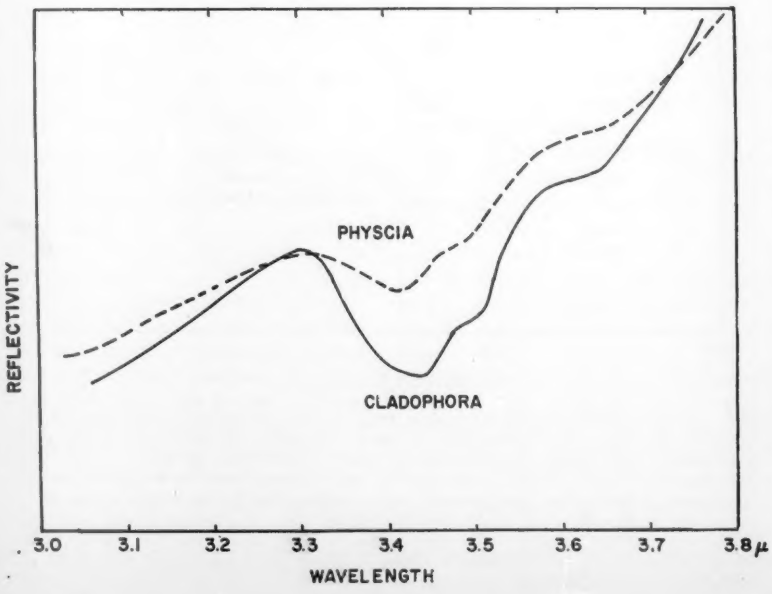


Fig. 3. (Top) Spectra of Mars in the regions 1 to 2.7 μ (*a*) and 3.8 to 4.2 μ (*b*). In *a* the ordinates of the portion of the curve to the left of the 1.88-μ absorption have been amplified by twofold. In *b* the spectrum of the sun is shown for comparison. The lowest curve marked "sky" is to be taken as the zero for the Mars spectrum. The nitrous oxide bands are equally strong in the spectra of the sun and Mars. Fig. 4. (Bottom) Laboratory reflection spectra of the lichen *Physcia* and the alga *Cladophora*. They show absorption at 3.67 μ due to carbohydrate constituents.

various regions of Mars with the 1-mm apertures. Five spectra were obtained of the region of Syrtis Major with the aperture removed and with 1-mm entrance and exit slit widths. The above spectra included only the wavelengths 2.7 to 3.8 μ or 3.1 to 3.8 μ.

Figure 1 shows a spectrum obtained with 1-mm slits that traversed the region of Syrtis Major as shown in the inset. Besides absorptions produced by water vapor and methane in the earth's atmosphere it has additional absorptions at 3.43, 3.56, and 3.67 μ which appear to be peculiar to the dark regions of Mars. A solar spectrum is shown in this figure for comparison, as is a spectrum of the region Amazonis, an area nearly free of dark markings. In Fig. 2 the spectra of these regions have been divided by the solar spectrum, taken at nearly the same air mass, to remove atmospheric absorptions and to derive the variation in albedo with wavelength. Thermal emission becomes increasingly important at longer wavelengths and may contribute a third of the radiation at 3.8 μ. Consequently Fig. 2 does not give the albedo variation accurately.

The intensity of the band in five regions of Mars was studied with the 1-mm aperture (8 sec of arc diameter). Table 1 gives qualitative intensities of the three absorptions together in these regions. In general the band was found to be present in four mostly dark regions centered on Syrtis Major, Pandorae Fretum, Mare Sirenum, and Mare Cimmerium. It was absent or weak in the bright regions surrounding Arabia and Amazonis. From this we conclude that the absorbing material is on the surface and that it is associated with the dark regions.

In addition to the spectra that were made in the region of the organic band, other spectra (Fig. 3) were obtained in the regions 1 to 2.7 μ and 3.8 to 4.2 μ, the extent of the detector's sensitivity. In the first range are bands of CO_2

Table 1. Intensity of organic band in different regions of Mars.

Region	Relative intensity	No. of spectra
Amazonis	0.3	2
Arabia	0.5	13
Mare Cimmerium	2	1
Mare Sirenum	2	2
Pandorae Fretum	2	7
Syrtis Major	2.5	11

previously reported by Kuiper (*4*, p. 358). These are shown quite well here, particularly the ones at 2 μ, which were in a region of low detector sensitivity in Kuiper's spectra.

No new absorptions, other than the organic bands, were found on Mars. The N_2O bands at 3.90 and 4.13 μ were no stronger in Mars spectra than in sun spectra. The CH_4 band at 3.3 μ was likewise equally strong in Mars and in solar spectra. The effective path length of CH_4 on Mars is four times a vertical path (two paths through the atmosphere each with a factor of 2 coming from the average over slant heights). For N_2O the effective path length is less than this because an appreciable fraction of the energy is emitted by the surface. However the ability to detect these gases is reduced by nearly tenfold relative to detection in the earth's atmosphere because of the low pressure on Mars. The amounts of CH_4 and N_2O, if present, are probably less than the amounts in the earth's atmosphere.

The presence or absence of these gases, and of oxygen too, is important to the question of biological life on Mars, for on the earth these gases are formed chiefly by biological activity. Oxygen results from photosynthesis, methane is formed by the decay of organic matter, and nitrous oxide is produced by bacteria in the soil (*7*).

Conclusions

The presence of the bands near 3.5 μ is confirmed. These bands are most probably produced by organic molecules, but carbonates also possess bands in this region (*8*). Their absorption is strongest at 3.4 and 3.9 μ with practically no absorption at 3.7 μ. Though carbonates are eliminated because of the disagreement in the details of the absorptions, it probably cannot be assumed that no inorganic molecule can explain the observed bands. The observed spectrum fits very closely, however, that of organic compounds and particularly that of plants (see Fig. 4).

It is tempting to assume, though this has not been demonstrated, that the dark regions that have appeared during the history of planetary observing also contain organic molecules. If this is true, then organic molecules are produced in localized regions in relatively short spans of time. Growth of vegetation certainly seems to be the most logical explanation for the appearance of organic molecules.

At first the band at 3.67 μ seemed to be an enigma, for it had not been found in any terrestrial plants. However it has now been found in the alga *Cladophora* (Fig. 4). It is apparently produced by carbohydrate molecules present in the plant. The attachment of an oxygen atom to one of the carbon atoms shifts the resonance of a hydrogen atom attached to the same carbon to a longer wavelength. Thus the evidence points not only to organic molecules but to carbohydrates as well. The strength of the band at 3.67 μ compared to its weakness or absence in plants may indicate a significant difference in plants that may be present on Mars and perhaps indicates a larger storage of food.

References and Notes

1. E. C. Slipher, *Proc. Am. Phil. Soc.* **79**, 441, (1938) (see plate III).
2. W. M. Sinton, *Sky and Telescope* **14**, 360 (1955).
3. V. M. Slipher, *Publ. Astron. Soc. Pacific* **36**, 261 (1924); P. M. Millman, *Sky* **3**, No. 10, 10 (1939); G. A. Tikhov, *Bull. Astron. and Geodet. Soc. U.S.S.R.*, No. 1 (8), 8 (1947).
4. G. P. Kuiper, in *The Atmospheres of the Earth and Planets*, G. P. Kuiper, Ed. (Univ. of Chicago Press, Chicago, Ill., 1952).
5. W. M. Sinton, *Astrophys. J.* **126**, 231 (1957).
6. This work was substantially aided by grant G3949 from the National Science Foundation.
7. G. E. Hutchinson, in *The Earth as a Planet*, G. P. Kuiper, Ed. (Univ. of Chicago Press, Chicago, Ill., 1954), pp. 392–405.
8. G. Schaefer, C. Bormuth, F. Matossi, *Z. Physik* **39**, 648 (1926).

Science in the News

National Standards for Teacher Certification To Be Studied under Carnegie Grant to AAAS

The American Association for the Advancement of Science has received an $81,000 grant from the Carnegie Corporation of New York to support an 18-month study of certification requirements for teachers of secondary-school science and mathematics. The grant was made in response to a proposal that was submitted to Carnegie by the National Association of State Directors of Teacher Education and Certification, an independent group that is made up of the chief certification officer in each of the states. Since the organization is not incorporated, and therefore not directly eligible for a Carnegie award, the AAAS will hold the funds and administer them in cooperation with NASDTEC. Work will commence on 1 December at headquarters that are being established in the AAAS building in Washington, D.C.

John R. Mayor, AAAS director of education, is part-time director of the new study. He will provide some leadership, but full-time responsibility for the investigation will be carried by the associate director, William Viall, who has just resigned his post as chief of the Bureau of Teacher Education and Certification for the state of New York.

Viall, immediate past president of NASDTEC, has been on the staff of the New York State Education Department since 1951. His experience there, and his earlier career, provide him with outstanding qualifications for his present assignment. He has served as teacher in a one-room country school, as instructor in a small-town junior high school, as assistant principal in a practice school for teachers, as professor of education and director of demonstration schools and student teaching in a teachers college, as director of elementary schools

William Viall

for a state department of education (New Hampshire), and as summer lecturer at a number of universities.

Objectives

It is hoped that the new study will provide a basis for establishing state and national standards of teacher certification and for promulgating reciprocity agreements among the states. At present such reciprocity exists only at the elementary-school level, where it is possible because there is a nationally accepted program for the education of elementary teachers.

However, there is not a single reciprocity agreement, even between two states, on any certification at the secondary-school level. This has been a major concern of the National Association of State Directors of Teacher Education and Certification.

The members of the association have concluded that to be most effective the study should be concentrated on a specified field. It was decided that the area of greatest need at the present time is that of science and mathematics.

Operation

The study will be conducted on a state, regional, and national basis. Initially, five regional groups will carry out status studies. The groups will all examine much the same type of material, then each will draft what it conceives to be an ideal program. To accomplish this, they will review current certification programs, special attention being given to those which are judged to be superior; the several statements that have already been prepared as a result of special state surveys; and the recommendations of curriculum groups and other appropriate bodies, such as the AAAS Cooperative Committee on the Teaching of Science and Mathematics.

In each state a committee of scientists, teachers, and professional education administrators will be appointed to serve under the director of teacher education and certification. These state groups will consider the results of the status studies and draw up a minimum training program for science and mathematics teachers that is in keeping with the conditions in their particular state. This program will be submitted to state authorities for tentative approval, with the understanding that further study is to be carried out by the National Association of State Directors of Teacher Education and Certification for the purpose of making a proposal at the national level.

The status studies are expected to take 9 months, and the state action, another 9 months. At the end of the 18-month period, a national conference will be held to examine the findings, to focus public attention on the work, to lay plans for the development of reciprocity agreements on a national basis, and to inaugurate studies in other disciplines.

While the members of the National Association of State Directors of Teacher Education and Certification are principally responsible for administration of certification requirements, they provide active leadership in the determination of these requirements in the various states. Through this AAAS-Carnegie study, it is hoped that the group may be able to establish a new framework for certification of teachers in the public schools.

Hesitancy of Europe To Invest in U.S. International Atom Program To Be Studied

The hesitancy of European investors to participate in the U.S.-sponsored Euratom program has led to a call by the Joint Congressional Atomic Energy Committee for a full study of the United States' international program for the development of atomic energy. In announcing the new study, Senator Clinton P. Anderson (D-N.M.), chairman of the committee, named Robert M. McKinney, a former U.S. representative with the International Atomic Energy Agency, to be its director. "The time is appropriate," the senator said, "for a reappraisal of our various international atomic energy programs and policies in terms of whether they are fulfilling their original purposes and premises, and, if not, what changes are necessary or desirable."

The study planned by the committee will include examination of the bilateral agreements of the U.S. that bear on the development of atomic energy, the work of the International Atomic Energy Agency, and the U.S.-Euratom relationship. Among the particular points to be examined by the study will be these: In industrial countries, should emphasis be placed, at this stage, upon broad-scale research, development, and demonstration programs or upon the construction and operation of commercial plants? Is sufficient attention being given to the special problems of less developed countries? What are the implications of the present international policies of the United States for our domestic atomic-equipment industry, and what impact will developments abroad have upon our domestic atomic power programs?

European Program Faltering

Behind the study is the fact that only two European utilities have submitted firm plans for the construction of atomic power plants with U.S. technical and financial aid. The deadline for such proposals was 20 October. Earlier in the year five letters of intention were received at the Brussels headquarters of Euratom, but these were only for the information of officials and did not commit the utilities to build plants. This response was disappointing to U.S. and Euratom officials, who had hoped that six or more plants would be constructed under the program. However, an increase in fuel reserves from known sources and the discovery of new reserves within the earth have made the energy problem in Europe less pressing than it was at the time Euratom was conceived.

McKinney has recently evaluated this situation in Europe during tours of atomic installations and while attending the meetings of the International Atomic Energy Agency. In addition to his past work with the IAEA, McKin-

ney served as a U.S. delegate to the second Atoms for Peace conference in Geneva and as chairman of a panel that reported to Congress in 1956 on the impact of the peaceful uses of atomic energy. His published statements over the past 10 years indicate that his views on the role of atomic energy have changed with changing conditions. In the 1956 report to Congress, McKinney stressed the need for a program which would use atomic energy to meet the power requirements of other countries. However, as fuel reserves built up, particularly in Europe, he altered his views on the role of atomic energy. Speaking before Congress in May of this year, he said: "We need to rethink from scratch the way in which the United States employs the peaceful uses of atomic energy as instruments of international relations . . . We must face the fact that Europe's economic needs for nuclear kilowatts have receded."

Cooperation Assured

The study, which is now getting under way, is expected to occupy McKinney and his staff until June of next year. Assurance has been given by both the Atomic Energy Commission and the State Department of their cooperation. Chairman McCone of the AEC has assigned a number of members of his staff, including John Hall, assistant general manager for international activities, to work with the Congressional group. A similar assignment of personnel has been made by the State Department.

In the light of the faltering of the Euratom program and of McKinney's past statements, there is reason to believe that the study of this country's international atomic energy programs may result in a recommendation for a basic shift in policy away from emphasis on reactor construction toward a new emphasis on research and development. Certainly both the trend of thinking among the members of the Joint Congressional Committee on Atomic Energy and developments in Europe support this expectation. Whatever the final recommendations may be, the study, which is the first to be made since the broad outlines of U.S. policy on international atomic energy programs were laid down 5 years ago, and the selection of McKinney to direct it, seem to promise a full and necessary review of the many facets of this country's "atoms for peace" program.

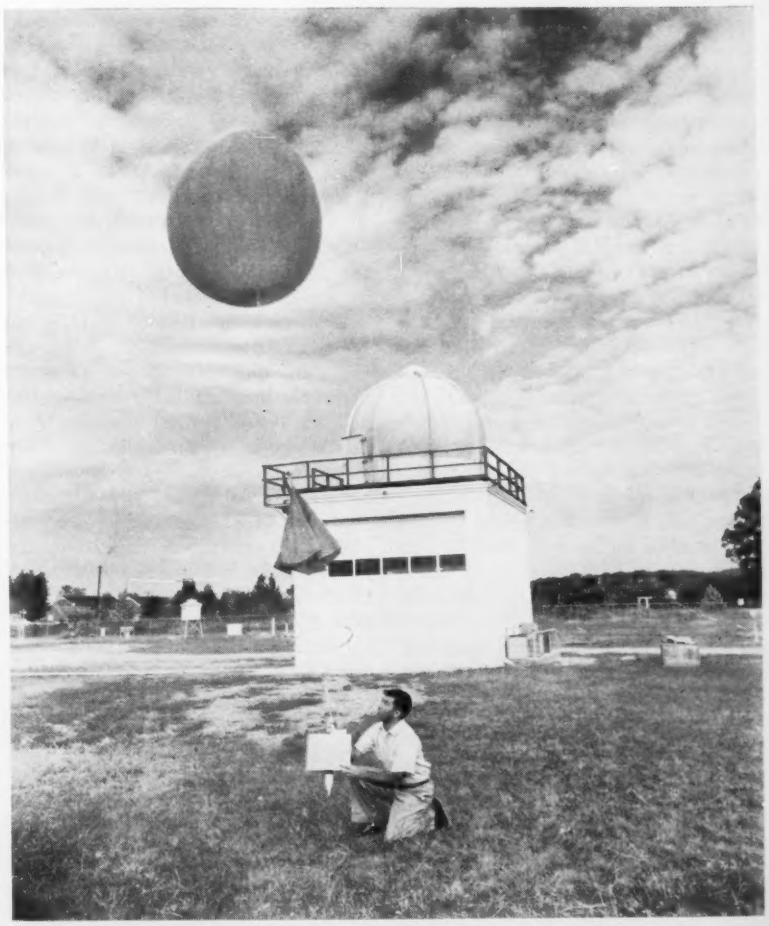
U.S. To Launch 10 Rockets in Week as Part of IGY Successor Program

Ten research rockets will be launched as the United States contribution to International Rocket Week, 16–22 November. The rocket series is part of the U.S. program for International Geophysical Cooperation–1959 (IGC–59), the continuation of the International Geophysical Year program of 1957–58. Responsibility for this country's activities in IGC–59 lies with the National Academy of Sciences' IGY Committee, which is headed by Hugh Odishaw.

The U.S. program for the rocket week is being coordinated internationally by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions.

The National Aeronautics and Space Administration will launch two rockets from Wallops Island, Va. One Nike-Asp will measure upper-atmosphere winds at heights to 150 miles; a second will investigate solar x-ray and Lyman-alpha emissions.

The Army Ballistic Research Laboratories plan to send up two Nike-Cajun rockets from Fort Churchill—in cooperation with Canadian scientists and the Government of Canada—and two specially assembled five-stage rockets from Wallops Island. The shots in Canada will be used to determine water-vapor content of the atmosphere from 18 to 60 miles up, while those at Wallops Island will measure charge densities at between 50 and 1000 miles. The latter altitude range includes the ionosphere, the charge density of which



The U.S. Weather Bureau collects data for International Geophysical Cooperation–1959. Here a bureau observer holds an airborne rawinsonde assembly, consisting of a balloon, parachute, and rawinsonde transmitter. The Fiberglas dome in the background houses the rawinsonde receiver.

governs the reliability of radio transmissions.

The Air Force Geophysics Research Directorate expects to send up a magnetometer in an Aerobee rocket that will be launched at Fort Churchill, while two rockets from Eglin Air Force Base, Fla., will carry instrumentation for micrometeorite experiments.

The Naval Research Laboratory will take part with an Aerobee rocket from White Sands, N.M., carrying equipment designed to record with high resolution a portion of the solar spectrum.

Each participating nation is expected to inform COSPAR of its International Rocket Week plans, for circulation to other participating nations. The week should produce valuable data on the world's upper atmosphere during a specified time period.

United States Participation

This country's participation in IGC consists of (i) contributed efforts from public and private institutions; (ii) two major programs on antarctic research and space science; and (iii) a small group of projects which were recommended by the IGY Committee and which are supported by the National Science Foundation. The contributed efforts include data-gathering by networks of stations such as those operated by the Weather Bureau and the National Bureau of Standards. Of the two major programs, that on antarctic research is supported by the National Science Foundation and the Navy, and that on space science is supported by the National Aeronautics and Space Agency and other government agencies.

The United States is operating 478 IGC stations on its own, and 204 on a cooperative basis with other countries. At the cooperative stations, the U.S. supplies equipment or personnel, or both. Brief notes on the programs planned in each of the IGC–59 disciplines or areas of special study follow.

Earth's Heat and Water Budget

Meteorology. Surface and upper-air meteorological observations are being made at 170 stations operated by the United States, and at 27 stations operated in cooperation with other countries. Special measurements of carbon dioxide and ozone concentrations in the atmosphere are being made at some stations, and some work is being done on oceanographic research vessels on the exchange of CO_2 between sea water and air.

In the Arctic Basin, a new floating station, Station C, has been established to take the place of Station A, which had to be shut down last year. At Station B (on Fletcher's Ice Island, or T-3) special surface observations, including carbon-dioxide and solar-radiation measurements, are continuing, while at Station C a full meteorological program, including upper-air soundings, is under way.

Glaciology. Continuing arctic glaciological work includes study of the behavior of glaciers in southern Alaska; study, in cooperation with Denmark on the Greenland icecap, of movement and ice mechanics, as well as tests of deep-drilling techniques for subsequent use in the antarctic; and, on the two floating stations, study of stratigraphy and petrofabric of the ice pack and the heat budget of the Arctic Ocean ice-sea-atmosphere system.

Among other projects in the United States, glaciologists reoccupied for the summer a station on Blue Glacier in Olympic National Park, to continue study of the mass and energy regimen of the glacier, the mode and mechanism of flow in the ice tongue of the glacier, the internal structure, and oxygen-isotope ratios.

Oceanography. Twenty-six U.S. and 11 cooperative stations are being operated in the oceanography program. Ship operations are being conducted in both the Pacific and the Atlantic, while profile studies in the Atlantic and study of current systems in the Pacific are being continued.

Marine geophysical studies are continuing at Drifting Station B, in the Arctic Basin, and oceanographic studies similar to those carried out at Station A during the IGY are continuing at the new drifting station, Station C.

With the cooperation of such groups as this country's Committee on Oceanography of the National Academy of Sciences, ICSU's Special Committee for Oceanic Research has developed definite plans for making further studies of the oceans, to culminate in an international cooperative investigation of the largest unknown area on earth, the 28,350,000-square-mile Indian Ocean, throughout a complete monsoon period in 1962–63.

Nuclear radiation. At 148 stations operated by the United States, and at 69 stations operated in cooperation with other countries, measurements of the radioactivity of the air, of solid particles deposited on the ground, and of precipitation at the earth's surface are being continued.

Upper Atmosphere, Sun, and Space

World Days. As part of the International World Days Service, the IGY World Warning Agency operated at Fort Belvoir, Va., by the North Atlantic Radio Warning Service of the National Bureau of Standards is now known as the World Warning Agency. The WWA issues IGC alerts and announces Special World Intervals. As during the IGY, a program of Regular World Days is also under way.

Airglow. At three U.S. stations, and at two stations cooperatively operated with other countries, automatic scanning photometers are in use. Launching of rockets carrying airglow observing equipment is another aspect of IGC–59.

Aurora. At 20 stations, all-sky cameras are continuing to photograph the aurora every minute. All-sky cameras are also in operation at nine stations cooperatively maintained by the United States and other countries. A new type of all-sky camera is being used in Alaska to determine auroral heights by triangulation as a part of broad spectroscopic studies of auroral phenomena and their dependence on height.

Visual, radar, and spectroscopic observations of the aurora are continuing at many locations. Altogether, there are 26 stations being operated by the United States in the aurora program for IGC–59, and 18 stations that are being operated cooperatively with other nations.

Cosmic rays. In the field of cosmic rays, 14 U.S. and six cooperative stations are in operation. Four institutions are conducting balloon observations in the United States and Canada. Rockets and several satellite vehicles have carried cosmic-ray equipment. An airborne neutron monitor is being used to survey the geomagnetic equator and to study latitude variations of cosmic-ray intensity. Neutron monitors, ionization chambers, and meson telescopes are being operated at many stations for continuous registration of cosmic-ray intensity.

Geomagnetism. Twenty-one stations are being operated by the United States

alone, and seven are being operated in cooperation with other countries, including four in Peru with the cooperation of the Instituto Geofisico de Huancayo. The regular United States magnetic observatories are continuing to supply data to the World Data Centers during IGC–59. The special networks established during the IGY to study the equatorial electrojet and sub-audio signals and their relationships to magnetic storms are also continuing operations.

Ionospheric physics. Thirty U.S. and 41 cooperative stations are being operated in the U.S. IGC–59 ionospheric-physics program. Vertical soundings are taken every 15 minutes with modern ionosondes, and more often on Regular World Days and during Special World Intervals. There will be continued studies of backscatter, transequatorial propagation, radio noise, whistlers, and ionospheric absorption of extra-terrestrial radio signals, and several groups will observe and analyze ionospheric effects upon satellite radio signals.

Solar activity. Thirteen stations are being operated by the United States in this program, which includes continuation of optical patrols of the sun's corona, plages, flares, sunspots, and active-region magnetic fields, supplemented by solar-radio-noise patrols and radio spectroscopic observation. Expeditions to Fuerteventura, in the Canary Islands, and to French West Africa, observed the total solar eclipse of 2 October 1959. The solar-activity program also includes special rocket experiments.

Space science. The United States' contribution to IGC–59 in space science is being made by several agencies through the Space Science Board. Results of appropriate launchings are expected to be made available to the World Data Centers and to ICSU's Committee for Space Research. The U.S. space-science program has been placed on as broad a basis as possible. By the end of 1959, about 75 sounding rockets and several satellites and space probes will have been launched as a contribution to IGC–59.

The satellite and space-probe contribution is largely being made by the National Aeronautics and Space Administration.

Contributions to the rocket sounding program are being made by many public and private institutions. Emphasis is being placed upon experiments relating to atmospheric structure, electric and magnetic fields, astronomy, energetic particles, and the ionosphere. The coming World Rocket Week is part of this program.

Earth's Shape, Crust, and Composition

Seismology. Most of the IGY network seismological stations have continued functioning during IGC–59. Two Benioff extensometers, or strain seismometers, are being operated in Chile and in Peru as cooperative programs; they are used to determine the strain pattern of the region. The program for studies of the structure of the earth's crust under the Andes is being extended to include a network for observations of local and regional earthquakes.

Gravity. Gravity determinations by United States groups are assisting in completion of a world network; gravity measurements made at sea by means of the Graf sea gravimeter and pendulum equipment are also being continued.

Longitudes and latitudes. During IGC–59 the U.S. Naval Observatory has continued to be the central agency for the moon-position program. Photographic observations of the moon, made with the dual-rate camera, and determination of astronomical longitudes and latitudes by means of the Danjon impersonal astrolabe are continuing at three stations—in Washington, D.C., in San Diego, and near Honolulu.

Antarctica

The United States program for scientific research in the antarctic during 1959 was developed by the NAS Committee on Polar Research in collaboration with various federal and private agencies in the United States. The program is being carried out under the direction and coordination of the National Science Foundation. Logistic support is furnished principally by the United States Navy. Coordination with international plans for continued cooperation in antarctic research has been effected through the National Academy's participation in the deliberations of ICSU's Special Committee for Antarctic Research.

The U.S. IGC–59 program in Antarctica includes projects in aurora, cosmic rays, geomagnetism, ionospheric physics, glaciology, meteorology, and oceanography. In addition, special programs are being conducted in geology, geodesy, cartography, and the biological and medical sciences.

Two United States antarctic stations, the Byrd and Pole stations, are staffed fully by American personnel. Hallett Station and the Scott-McMurdo complex have joint New Zealand-United States staffs. Wilkes Station and Ellsworth Station have Australian and United States personnel, respectively.

World Data Center A

World Data Center A continues as one of the three data centers set up during the IGY. World Data Center B is in the U.S.S.R., and World Data Center C is in Western Europe, Australia, and Japan

Center A was established in 11 institutions in the United States in accordance with the academy's belief that the interests of science would best be served by housing the data in institutions with histories of scientific interest and competence in particular geophysical disciplines. Data collected during the U.S. IGC–59 program will be collected in Center A and will be exchanged with the other World Data Centers.

Moon Pictures Show "Monotonous" Other Side

The Soviet Union has succeeded in taking a "considerable number" of photographs of the far side of the moon. The pictures were made during a 40-minute period when the satellite, Lunik III, was about 40,000 miles beyond the moon. After being processed in the satellite, the photographs were transmitted to the earth by what the Soviet news agency Tass called a "photo television" apparatus. The opinion of scientists on the value of the pictures released to date varies, but no one has questioned their authenticity.

The release of one of the moon pictures last week answers the questions that became current during the satellite's long first orbit of the earth and the moon. Although reports at the time of launching indicated that photographic equipment was being carried by the satellite, no confirmation or denial of this point was made by Soviet authorities. At the time, the suggestion was made that the Soviet Union was being cautious as usual, to avoid the possibility of having to acknowledge failure.

Exercising its prerogative, the Soviet Union immediately assigned a special committee of its Academy of Sciences to name the various features of the moon's far side revealed in the photographs. The surface, although generally

"monotonous," in the words of an official Soviet statement, had the following geographical features: a large irregular indentation which was named the Moscow Sea; two hills, named Lomonosov and Tsiolkovsky; a crater, named Joliot-Curie; the "Sea of Dreams," and the "Soviet Mountains." The far side seems to be a great deal smoother than the side facing the earth. Early comments by scientists indicate that this smoothness confirms a prediction made in past years by astronomers. In his announcement, Aleksandr Mikhailov, director of the Pulkovo Observatory, said that the monotony of the newly revealed surface was "beyond doubt associated with the question of the origin of the configuration of the moon."

Apart from the photographs themselves, the most remarkable aspect of the latest Soviet space effort is the degree of skill required to design the devices that exposed, developed, and transmitted the pictures.

Nobel Awards in Chemistry, Physics Go to Czech and Two Americans

The first Nobel Prize ever to go to a citizen of Czechoslovakia has been awarded by the Swedish Academy of Sciences to Jaroslav Heyrovsky, a chemist who developed the polarographic method of chemical analysis. The laureate, who is head of the Polarographic Institute in Prague, devised the method in 1922 and lectured on it in this country during a tour in 1933. It is a method for measuring voltage-current relationships in solutions by means of a polarized microelectrode. The system, used in microanalysis, has proved to be particularly useful in metallurgy.

When informed of the award, Heyrovsky said: "My happiness is twofold, since this is the first time in the history of the Nobel Prize that a citizen of the Czechoslovak Republic has received it. It is further evidence that new roads for still closer and more fruitful cooperation between scientists of both world systems now are opening up."

Two Americans Win Physics Award

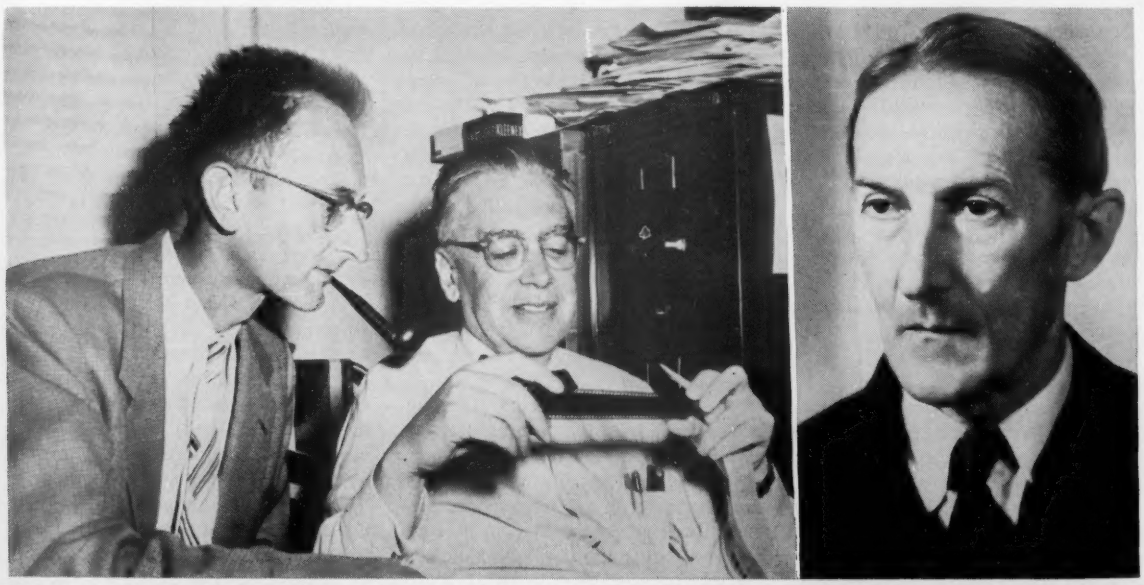
Simultaneously, the Swedish Academy announced that Owen Chamberlain and Emilio Segrè, both professors at the University of California, will share the Nobel Prize in physics for their demonstration of the existence of the antiproton. (Chamberlain is currently at Harvard University as a visiting lecturer.) The two men, who are 39 and 54, respectively, conducted their experiments in the bevatron at the university's Radiation Laboratory in Livermore, Calif. The award-winning work has contributed significantly to the understanding of the nature and construction of matter.

The Nobel prizes in chemistry and physics, and the physiology and medicine award announced earlier, each amount to $42,606. The presentation ceremony will take place in Stockholm on 10 December.

Soviet Scientists Visiting United States Atomic Installations

V. S. Emelyanov, head of the Main Administration for Utilization of Atomic Energy in the U.S.S.R., and a party of eight Soviet scientists yesterday began a 15-day tour of some of this country's major atomic-energy installations. The eight centers that are being visited are devoted to the peaceful uses of atomic energy; the group will see work in high-energy physics, controlled thermonuclear fusion, and civilian power reactor development. The trip will also include a visit to a uranium mine and a uranium mill. This tour for the Russian scientists is similar to one that was arranged last month in the U.S.S.R. for a team of American scientists headed by John A. McCone, chairman of the U.S. Atomic Energy Commission.

At the conclusion of the Russian visit, about 20 November, Emelyanov and McCone will discuss further ways of exchanging information and of col-



Nobel award winners. Three recipients of the 1959 Nobel Prizes are (left to right) Owen Chamberlain and Emilio Segrè, both of the University of California, who shared the physics award, and Jaroslav Heyrosky of Czechoslovakia, who won that country's first Nobel award for his discovery of the polarographic method of chemical analysis.

laborating, probably under the sponsorship of the International Atomic Energy Agency. At a conference in Washington on 15 September the two officials announced that they had agreed in principle that their respective countries should make every effort to utilize the IAEA as a repository for information on the peaceful applications of atomic energy and to encourage and aid the agency in the dissemination of this information to all nations.

Members of the United States team that went to the U.S.S.R. report that the Soviet nuclear work they saw was of high caliber and in general parallel with ours. McCone stressed the speed with which the Soviet scientists can carry out research projects. To illustrate, he mentioned that they designed and built their huge thermonuclear research device "Ogra" in 10 months, while it is taking about 2½ years to complete our similar facility at Princeton. McCone also remarked that at Obninsk there was a fast neutron reactor which had been designed and built in only a year's time.

Churchill College Aided by Ford

At the recent ground-breaking ceremony for Churchill College at Cambridge University, it was announced that the Ford Foundation had granted one million dollars to the new institution. The total cost of the college will be about £3,500,000 ($9,800,000), including buildings and endowments. About half has now been collected.

The Ford gift is expected to cover the operation of the college, including payment of faculty and all administrative costs, for the first 5 or 6 years. British funds will meet the building costs.

Of the 600 to 700 students who will eventually attend Churchill College, about 70 percent will study science and technology. Although it will be years before the buildings are finished, the first students are scheduled to be admitted in 1961.

Grants, Fellowships and Awards

Chemistry. The board of editors of *Talanta*, international research journal in analytical chemistry, have announced a new award, to be known as the Talanta Medal. The publishers, Pergamon Press, are providing the funds for this medal, which will have a value of 100 guineas, and which will be awarded for outstanding contributions to analytical chemistry. The medal will not ordinarily be awarded more frequently than once a year, but no attempt will be made to award it at stated intervals.

Any outstanding paper or papers contributed to *Talanta* will automatically be considered for the award. Other work may be proposed by any member of the advisory board for consideration. The award will not be confined to current work. The medal will only be awarded on the unanimous recommendation of a committee composed of the editor-in-chief of the journal, the regional editors, and the chairman of the advisory board, supported by two-thirds or more of the members of the advisory board, all of whom are leading analytical chemists. For further information, write to Pergamon Press, 4 and 5 Fitzroy Square, London W.1, England.

Natural sciences. The Weizmann Institute of Science, Rehovoth, Israel, has announced the 1960–61 Chaim Weizmann memorial fellowships in the natural sciences. The awards are intended for scientists with several years of postdoctoral research experience. It is expected that the candidate will have worked in a field close enough to one of the subjects under investigation at the institute to be able to join an existing research team. The stipend includes round-trip fare by air for the scientist and his family and an adequate living allowance in Israel in local currency. The institute endeavors to help find suitable accommodation. Applications should reach the Academic Secretary, The Weizmann Institute of Science, Rehovoth, Israel, not later than *10 December*.

Travel to biology meetings. The Division of Biology and Agriculture of the National Academy of Science–National Research Council has funds to support travel to the following international congresses scheduled for 1960: Photobiology, Copenhagen, 31 July to 5 August; Histochemistry, Paris, 29 August to 1 September; Cell Biology, Paris, 3–8 September; and Embryology, Pallanza, Italy, 15–20 September. Requests for application forms should be directed to the Division of Biology and Agriculture, NAS–NRC, 2101 Constitution Ave., NW, Washington 25, D.C. Awards will be in an amount roughly equivalent to round-trip air fare to the congress. Completed application forms must be in the division office not later than 1 January 1960.

News Briefs

Two United States earth satellites have plunged out of orbit. The Air Force reports that its 1700-pound Discoverer VI, launched from Vandenberg Air Force Base, Calif., on 19 August, ceased orbiting on 20 October during its 965th pass around the earth. At Cambridge, Mass., the Smithsonian Astrophysical Laboratory reports that Explorer IV, launched 26 July 1958, apparently fell from its orbit on 22 October. Explorer IV, an 80-inch-long tube weighing 38.43 pounds, was launched from Cape Canaveral, Fla., by the Army.

* * *

The 50th anniversary of the mental-health movement in the United States will be celebrated by some of its noted pioneers and the country's leading psychiatrists at the annual meeting of the National Association for Mental Health in Philadelphia, 19–21 November. Arthur S. Flemming, secretary of the U.S. Department of Health, Education, and Welfare, will be the banquet speaker. Psychiatrist George S. Stevenson, probably the best known of the mental-health leaders here and abroad, will receive the tribute of the assembly on his retirement, at 66, as NAMH national and international consultant.

* * *

The population of the United States, including residents of Hawaii and Alaska, reached 178,252,000 on 1 September.

* * *

Formation of the Canadian Science Fairs Council has been announced by a committee representing Canada's professional, scientific, engineering, and educational organizations. The council will coordinate and promote the science-fair movement, already well developed in the United States. Henri Favre, head of the department of chemistry at the University of Montreal, is chairman of the new council's steering committee, which will have headquarters in the offices of the Chemical Institute of Canada, 18 Rideau St., Montreal.

* * *

The American Type Culture Collection (2112 M St., NW, Washington 7, D.C.) has announced that it has available new editions of two important publications: the *Viral and Rickettsial Registry and Distribution Center* and the *Catalog and Registry of the Plant Viruses.*

Scientists in the News

Roy W. Johnson, director of the Advanced Research Projects Agency of the Department of Defense, has announced his intention of resigning from the post in the near future to begin a career as a professional artist.

Three Sigma Xi national lectures will be given at a number of colleges and universities during November. **Willem J. Luyten**, professor and director of the observatory, University of Minnesota, will discuss "Stellar Populations, Dying Stars, and Stellar Evolution"; **John Verhoogen**, University of California, Berkeley, will discuss "Temperatures within the Earth"; and **R. F. Dawson**, Columbia University, will discuss "The Biosynthesis of Tobacco Alkaloids."

R. W. Meadows, principal scientific officer, Radio Research Station, Ditton Park, England, is visiting the U.S. for about four months. He arrived 28 October 1959. He will spend approximately three months at the National Radio Astronomy Observatory, Green Bank, W.Va.

Dietrich Bodenstein, gerontology branch, U.S. Public Health Service, Baltimore City Hospital, will become chairman of the department of biology, University of Virginia, on 1 February 1960.

Joseph W. Weinberg has been appointed associate professor of physics at Western Reserve University.

John A. Clements, physiologist in the clinical investigation branch, Army Chemical Center, Maryland, has been invited to work as a visiting scientist in the Cardiovascular Research Institute at the University of California Medical Center, San Francisco, for the academic year 1959–60.

Gladys L. Hobby, who has been associated with the research division of Charles Pfizer and Company, has been appointed director of a special microbiologic research laboratory recently established under the research division of the U.S. Veterans Administration. The new laboratory, which will be concerned primarily with the development of methods for prevention and control of infection, has been constructed at the Veterans Administration Hospital in East Orange, N.J.

Albert Szent-Gyorgyi, Nobel Laureate and research director at the Institute for Muscle Research, Marine Biological Laboratories, Woods Hole, Mass., will be awarded the bicentennial medal of the City College Chemistry Alumni Association for scientific achievement. The presentation will be made at the annual dinner of the association, to be held in New York City, 29 December 1959.

Clarence J. Hylander, executive director of the American Institute of Biological Sciences, has been appointed visiting professor of biology at Bowdoin College for the academic year 1959–60.

Joseph S. Smatko, associate professor and acting head of the department of chemical engineering at the University of Southern California, has been appointed senior scientist in the Advanced Development Section of Hoffman Laboratories Division, Hoffman Electronics Corp., Los Angeles, Calif.

Ray J. Howe, curator of education at the Kansas City Museum, Kansas City, Mo., has been appointed chairman of the education department of the Academy of Natural Sciences, Philadelphia, Pa.

Theodore E. Friedemann has resigned from the position of scientific director, U.S. Army Medical Research and Nutrition Laboratory, located on the grounds of Fitzsimons Army Hospital, Denver, and has joined the research staff of the chemistry department, University of Colorado, Boulder. He has been retained as consultant to the laboratory.

Francis J. Weiss, formerly with the Sugar Research Association and now a scientific consultant on food and nutrition, has joined the staff of the science and technology division of the Library of Congress. He will review the foreign literature in certain fields of the physical and biological sciences and report on developments.

Robert A. Ralston, research forester at the Wausau, Wis., Forest Research Center, has been transferred to the Central States Forest Experiment Station's Columbia (Mo.) Research Center. As director at Columbia, Ralston will head the center's research program in forest management, economics, insects, diseases, and range.

Bruce H. Sage, professor of chemical engineering at California Institute of Technology, will receive the 1959 William H. Walker Award of the American Institute of Chemical Engineers at the 52nd annual meeting in San Francisco, 6–9 December.

Gordon Lindenblad, biochemist, has been appointed research supervisor at the Radioisotope Laboratory, Section of Analytical and Physical Chemistry of the Squibb Institute for Medical Research, New York.

Irene M. Strieby, chief librarian of Eli Lilly and Company has retired, after having been with the company for 22 years. She became library consultant in 1956 and archivist in 1958.

Franz Schrader, Da Costa professor emeritus of zoology, and **Sally Hughes-Schrader**, research associate at Columbia University, have accepted appointments as visiting professor and research associate, respectively, in the department of zoology at Duke University.

Harold E. Edgerton, professor of electrical measurements at Massachusetts Institute of Technology, has received the Progress Medal Award of the Society of Motion Picture and Television Engineers.

E. J. Bloch, director of the Atomic Energy Commission's division of production, has been appointed assistant general manager for manufacturing. **George F. Quinn,** deputy director of the division of production, succeeds Bloch as director.

Edward H. Glade, former assistant director for headquarters operations and services, division of construction and supply, has been appointed director of the newly created Office of Headquarters Service.

W. E. K. Middleton, head of the photometry and optical instruments section, Division of Applied Physics of the National Research Council of Canada, has received the Frederic Ives Medal of the Optical Society of America.

Harold C. Stuart, professor of maternal and child health, emeritus, of Harvard University, received the Borden Award of the Borden Company at the 28th annual meeting of the American Academy of Pediatrics.

Book Reviews

On the Track of Unknown Animals. Bernard Heuvelmans. Translated from the French by Richard Garnett. Hill and Wang, New York, 1959. 558 pp. Illus. + plates. $6.95.

This is a book about animals that *might* exist, in contrast to the ordinary zoological treatise on animals that *do* exist. Heuvelmans calls it an "excursion on the frontier of science and fantasy." In exploring the subject—the emergence of species in the realm of human awareness—from the vague legends or hunter's tale to the point of acceptance by taxonomists, the author treats the early concepts of many real and many imaginary animals. Among the mammals discussed are the anthropoid apes, several monkeys, various apemen, the abominable snowman; pygmy species of elephant, rhinoceros, hippopotamus, and lion; and kouprey, marsupial tiger, *Diprotodon*, and a host of others. The birds include the moa, dodo, kiwi, and cahow; the reptiles include the giant anaconda, crocodiles, and even dinosaurs and pterodactyls.

This is an interesting area that is generally avoided by zoologists. Much field investigation of ethnozoology, much library research on the history of science, and much psychological analysis of human gullibility could be carried on here. I was disappointed to find that Heuvelmans was interested only in the superficial and sensational aspects of the subject. An impressive bibliography of technical books and papers is provided for each chapter, but the passages quoted from these sources are not the passages the original authors would consider most significant. Tales of travelers and accounts from local newspapers are given much credence. One must read carefully to find the author's disclaimers of the tales that even he cannot profess to believe.

Quotations from reliable sources are used to support very doubtful theories. For example, although there are no records of pterosaurs since Cretaceous times, the following statement is quoted from J. Z. Young's *Life of Vertebrates*:

"Nearly all specimens have been found in marine deposits and they seem to have been fish-eaters, but this does not prove that none lived on land, where the chance of fossilisation would have been much less."

This quotation precedes, and is made in such a way that it seems to support the following statement by the author:

"Thus it is not impossible that flying lizards might have survived until today in places inland without leaving the least trace of a fossil."

The phrase "not impossible" is the key to most of the author's conclusions. Throughout the book, evidence has been selected to support two prevailing themes. The first might be summarized thus: Some real species were first heard of through reports at which leading scientists scoffed, and some supposedly extinct types of animals have recently been discovered alive; therefore, it follows that any animal tale may be true, and that any type of animal may still survive, because how can one have absolute proof to the contrary?

The second theme is more positive: Established scientists have reactionary minds that are closed to new concepts, and they stubbornly refuse to recognize a new species long after sensible people have accepted it. These scientists are particularly unreasonable when they require that a specimen be found and studied.

Now, in regard to this latter theme, I know many systematic zoologists, and their minds are quite open to the possibility that new species exist; in fact, they spend much time searching for and describing new species. Unlike the author of this book, they try earnestly to distinguish truth from fantasy, and they do not think that the existence of a species can be proved by argument. As a result of their integrity on this score, the current checklists of animals pretty faithfully reflect what is known of the real faunas.

I noted with regret that five names of doubtful validity have been tossed into the already crowded taxonomic hopper. In an earlier French edition of the book (*Sur la Piste de Bêtes Ignorées*, Paris, 1955), Heuvelmans provided generic and specific names, *Dinopithecus nivalis*, for the general concept of the abominable snowman that is supposed to inhabit the Himalayas, and the names *Leo maculatus* and *Mellivora ratel maxima* for African carnivores, also with vague application. *Dinopithecus* is a preoccupied name, and in the present work it is replaced by *Dinanthropoides*. These names are well hidden in the text, and I may have overlooked others. Based on animals that may not exist and lacking diagnoses, comparisons, type specimens, or type localities, such names are anachronisms in 20th-century nomenclature.

Hoaxes, which are common and which contribute largely to the scientists' skeptical attitude that so exasperates the author, are passed over lightly. I find no mention of Piltdown man in the book. Heuvelmans admits that the tale of modern dinosaurs in New Guinea is beyond belief, but only after the full flavor of the story has been extracted.

A tremendous amount of reading must have gone into the preparation of the book, and a broad understanding of world fauna is apparent. The book's essential shallowness is evidenced, however, by many errors—such as the placement of the American marsupial *Marmosa* in Australia, and the statement that the only rats in Australia were brought in by man. Actually murine rodents that were not introduced by man make up about one-fifth of the known kinds of Australian mammals.

As popular entertainment, much can be said for this book. It is obviously designed and written to appeal to uncritical and not-too-well-informed readers. It is up-to-date, and it includes such recent discoveries as *Neopilina*. It is easy to read and well-illustrated. The chapter on the abominable snowman brings together a vast amount of otherwise scattered material on a currently popular subject. The bibliography is thorough and well-arranged.

Science fiction writers should find

here many points of departure for their flights into fantasy. The already great gullibility of the reading public will be increased by the book, and some eager amateur zoologist just might be so stimulated by it that he will go out and blunder onto a new kind of animal. As the author would say, it is "not impossible."

DAVID H. JOHNSON
U. S. National Museum,
Smithsonian Institution

Purchase Guide for Programs in Science, Mathematics, Modern Foreign Languages. Prepared by the Council of Chief State School Officers with the assistance of Educational Facilities Laboratories, Inc., and others. Ginn, Boston, Mass., 1959. vii + 336 pp. Paper, $3.95.

Under Title 3 of the National Defense Education Act, elementary and secondary schools (grades 4 through 12) will be able to purchase equipment for science, mathematics, and foreign language classes in far greater quantities than their present abilities allow. Educational administrators, teachers, and supervisors who need assistance in selecting equipment may turn to this publication for helpful suggestions.

The *Guide* consists of a subject list of the items recommended for use in teaching biology, chemistry, elementary science, general science, physics, mathematics, and modern foreign languages. Each item suggested for use in science is classified under one of the following headings: "Basic," "Standard," or "Advanced." This classification, with one exception, is the same for mathematics: "Additional" replaces "Advanced." In the section on modern foreign languages, special functional designations are used. Definitions of these terms are included in the *Guide*. The reader should study these terms carefully in order to interpret the recommendations and intentions of this list.

Each item of the alphabetical list is coded in one or more of the subject areas. The descriptions include brief specifications which generally provide enough information to assist substantially in making a better decision for purchasing equipment. There is no mention of cost, nor is there a commercial publisher or manufacturer associated with the items.

A most interesting feature of this publication is the guidelines offered through the use of essays. In general, these essays explain and clarify the modern trends in science, mathematics, and language education. Readers who are not familiar with these ideas will enjoy the essays and will find good suggestions for improving the physical setting of instruction in the various courses. For example, the description of a modern foreign language laboratory presents a new concept in the teaching of this subject. The description includes sketches and charts illustrating the use of a language laboratory.

The final items in the *Guide* are a bibliography of books for the school library and a directory of publishers and book dealers.

The foreword points out that all of the lists are necessarily incomplete and that they are to be regarded as open at both ends. Thus, the writers of the *Purchase Guide* recognize the dangers inherent in such a project and publication. Ways must be found to keep this *Guide* up-to-date, else in only a few years, it may become actually harmful, because it might serve to perpetuate the use of old equipment and traditional method and course content. Scientists should welcome the invitation from the Council to provide this assistance on a continuing basis.

The Council of Chief State Officers is to be congratulated on this significant contribution to education. It seems almost certain that this *Purchase Guide* will contribute greatly to the success of the National Defense Education Act of 1958. It is also a most encouraging sign in that the council sought the active support of scientists and language and library experts in this effort. Evidence of this is seen in the contribution of the National Bureau of Standards, the fact that the education officers of the American Association for the Advancement of Science, the American Chemical Society, and the American Institute of Physics, and persons nominated by the American Institute of Biological Sciences and the Modern Language Association were members of the advisory Committee of Seven, and in the participation of such agencies as the School Mathematics Study Group (sponsored by the National Science Foundation).

The project was organized and administered by Edgar Fuller, executive secretary of the Council of Chief State School Officers. The foreword was written by George E. Watson, state superintendent of public instruction in Wisconsin and president of the council. As Watson states, "This *Purchase Guide* is a pioneering effort in American education."

J. A. BROWN
School of Education,
University of Delaware

Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) described by Edward Meyrick. vol. 3. *Tortricidae, Olethreutidae, Noctuidae.* J. F. Gates Clarke. British Museum (Natural History), London, 1958. 600 pp. £6.

It is a pleasure to announce the appearance of volume 3 of Clarke's monumental work; volumes 1 and 2 were reviewed earlier [*Science* **122**, 1274 (1955)]. In volume 3 the species of Tortricidae and Olethreutidae are covered, as well as one species of Noctuidae. As in the previous volumes, all of the species are illustrated, and dissections show the taxonomically essential characters. The illustrations are superbly reproduced photographs, microphotographs, and, in some cases, drawings. The text comprises full bibliographic citation of the original publication and type locality, as well as the present taxonomic disposition of each species, citations of type specimens, and captions for the illustrations. The volume is produced in the same sumptuous manner as the earlier ones. It will certainly serve for a long time as the point of departure for future taxonomic studies of the families and genera treated.

F. R. FOSBERG
Falls Church, Virginia

Eskimo Prehistory in the Vicinity of Point Barrow, Alaska. *Anthropological Papers,* vol. 47, part 1. James A. Ford. American Museum of Natural History, New York, 1959. 272 pp. Illus. + plates. $4.75.

Ford's monograph reporting on the 1931-32 and 1936 excavations, mainly on the Birnirk culture site near Point Barrow, Alaska, is a work of major importance in Arctic prehistory. Excavation of frozen refuse mounds was limited to the time during the short summer when the ground thaws. Ford

briefly recounts in his introduction some nonarcheological experiences such as participating in the harpooning of bowhead whale from a skin boat (to collect the skull), helping castrate, mark, or kill (for skins and camp meat) 12,000 reindeer, traveling 1300 miles by Model-T Ford snowmobile (to secure supplies), and taking 200-mile dogsled jaunts (to collect asphalt for winter fuel).

The bulk of the report is a detailed description of the artifacts recovered, and the reader will agree with Ford's characterization of Eskimo culture as "gadget-burdened." Of particular interest is Ford's analysis of the chronological development of harpoon-head types in the Western and Canadian arctic areas (summarized in bar charts in Figs. 113 to 117). Trait-comparisons and frequency of shared-elements with other arctic culture complexes lead Ford to agree with earlier conclusions that the Birnirk culture phase at Point Barrow was derived from the Bering Strait region to the south, and that the Thule culture of the central and eastern arctic is derived from the Birnirk. Ford is able to tie the later Point Barrow site sequence in with the tree-ring dated sites of the Kobuk River to the south, but he believes that the radiocarbon dates for the Ipiutak culture are in error (much too recent). A valuable appendix by T. D. Stewart deals with the human skeletal material recovered and makes meaningful, at last, the information earlier provided for the Point Barrow materials by Hrdlička.

ROBERT F. HEIZER
Department of Anthropology, University of California, Berkeley

International Directory of Radioisotopes. vol. 1. *Unprocessed and Processed Radioisotope Preparations and Special Radiation Sources.* International Atomic Energy Agency, Vienna, Austria, 1959 (order from International Publications, 801 Third Ave., New York). xiii + 264 pp. Paper, $3.50.

For some years radioisotopes and radiation sources have found a ready use as tools for scientific research, and their application to such activities as agriculture, industry, and medicine is now steadily increasing. In view of this fact, the secretariat of the International Atomic Energy Agency has collected information on the sources of supply, nomenclature, and procedures for obtaining radioisotopes, and the prices of the radioisotopes (when this information was available). This information is made available in the *Directory*, which will be published in two volumes.

The contents of volume 1 are: "Safe handling of radioactive materials"; "Suppliers of radioisotopes" (entries are alphabetically arranged and include mailing addresses); "Additional information on radioisotope production" (information that arrived too late for use in the main section or about activities still in the planning stage); "Definition of terms"; "Information on tables"; and "Tables of radioisotopes."

Volume 2 will contain a list of the labeled compounds of carbon-14, hydrogen-3, iodine-131, phosphorous-32, and sulphur-34.

The Open Sea: Its Natural History. Part 2, *Fish and Fisheries.* Sir Alister Hardy. Houghton Mifflin, Boston, Mass., 1959. xiv + 322 pp. Illus. + plates. $7.50.

I don't know who will derive more pleasure from this book, the general reading public which will discover a new world, or the biologist who will find a most readable account of a vast and complex topic with which he may be, more or less, familiar. The book deals mainly with the natural history of fishes, around the British Isles. But since British fishermen go pretty far offshore to ply their trade, and since the North Sea and part of the adjoining North Atlantic are the oceanic areas about which we know the most (little as that may be still), Sir Alister has a lot to tell. With this selection of geographic area, it is only natural that the herring found on one side (chapter 3) and the plaice (chapter 8) and "Hake, haddock, cod and co." (chapter 11) found on the other side are treated in more detail than other fishes. The book deals not only with fishes and how they are caught, but as could be expected from the author of *The World of Plankton*, also with the invertebrates, whether they float in the open sea or crawl on the sea bottom. Some of the passages on the natural history of these benthic invertebrates and their relationships to the lives of fishes are every bit as fascinating as the treatment of the fishes themselves. Sir Alister belongs to the outstanding group of British biologists who have been actively concerned with the fate of the North Sea fisheries. Two chapters, one a concise and hearteningly simple treatment of 'the overfishing problem' and the other entitled "The ecologist and the future," bear witness to this concern.

A reviewer of this book's companion volume, *The World of Plankton*, wrote of Sir Alister's exuberance and contagious excitement in dealing with his subject. This is also true for the present volume, and if you feel yourself sidetracked at one or two points, you willingly follow the lead of the enthusiastic observer who says: "Now this is really interesting, come with me, I must show it to you and tell you more about it."

There is a chapter on marine mammals in which sea-going Eskimos are covered, and gigantic "sea serpents" get honorable mention.

If the book had only black-and-white drawings and photographs, it would be well illustrated. A friend who saw the original color sketches for the book says that the book's color plates have lost much in the process of reproduction. I quite believe this, but the photographs are still beautiful and set an example by their pleasing arrangement of that kind of information which only good, color pictures can convey.

JOHN E. BARDACH
School of Natural Resources, University of Michigan

New Books

The Age of the World. Moses to Darwin. Francis C. Haber. Johns Hopkins Press, Baltimore, Md., 1959. 314 pp. $5.

The Boy Engineer. Edward L. Throm. Golden Press, New York, 1959. 248 pp. $3.95 (juvenile). The story of engineering is traced from the time of the cave dweller to the man who builds a machine to do his work—the tools of Peking man, the great pyramids of ancient Egypt, bridges and canals, and globe-encircling rockets.

Classic Papers in Genetics. James A. Peters, Ed. Prentice-Hall, Englewood Cliffs, N.J., 1959. 288 pp. Paper, $3.95.

The Relationship between Nucleus and Cytoplasm. Proceedings of a symposium. Academic Press, New York, 1959. 276 pp. $12. This symposium, organized by the International Society for Cell Biology, was held in Brussels, 9-13 June 1958.

What Is Cybernetics? G. T. Guilbaud. Translated by Valerie MacKay. Criterion Books, New York, 1959. 134 pp. $3.50.

Zulu Journal. Field notes of a naturalist in South Africa. Raymond B. Cowles. Univ. of California Press, Berkeley, 1959. 281 pp. $6.

Reports

Photoelectric Technique for Measuring Eye Movements

Abstract. By the system described, the movement of a stimulus and the correlated tracking movements of the eye are recorded simultaneously. The technique for measuring the eye movements consists of detecting and amplifying by photomultiplication the total amount of light passing through a small slit upon which is imaged a small portion of the light-dark field represented by the iris and sclera of the eye. This total amount of light varies directly with the angular position of the eye.

The two standard methods for measuring eye movements, the corneal-reflex method and its numerous variations, and the electric method which is based upon measuring the difference in potential between the front and back of the eye, have been and are useful for many purposes. These methods, however, have certain disadvantages, one of which is the difficulty of coupling them easily with a system for generating a variety of stimuli whose structural attributes, velocity, and magnitude of displacement can be varied systematically and related directly with the tracking motions of the eye (*1*).

A more general disadvantage of these methods is their lack of efficiency in generating data. The present method overcomes these disadvantages and has, in addition, certain specific advantages (*2*).

The principle of the technique is based upon detecting the difference in reflectance between the iris and sclera of the eye in such a way that this difference can be expressed as proportional to the angular rotation of the eye. Figure 1 illustrates the principle. A portion of the eye as seen about 45 degrees laterally to an observer's direct line of sight is imaged on a surface containing a slit whose dimensions are approximately 1 mm wide by 1 cm long. The slit is parallel to the horizontal meridian of the eye. As the eye moves laterally right or left, more or less of the image of the iris falls upon the slit; hence more or less of the total light incident upon the surface containing the slit passes through the slit. Immediately behind the slit is the photocathode of a photomultiplier tube. The output of the tube thus becomes a signal whose magnitude is in known proportion (through calibration) to the lateral rotation of the eye.

The output of the photomultiplier tube (*3*) is coupled to an electronic switch (*4*) through an impedence-transforming amplifier. A variable high-voltage power supply (0 to 1000 volts d-c) with gas-tube regulation is provided for the photomultiplier tube. The amplifier is of a difference configuration type with high d-c stability and moderate voltage gain (20 to 1).

The entire detector assembly consists of the photomultiplier tube, a simple lens system (triplet) which focuses the desired portion of the eye on the slit which is located directly in line with and just in front of the photocathode of the tube, the adjustment mechanism for positioning the detector with respect to the eye, a mounting arm, and a headpiece to which the entire detector assembly is attached (*5*). The detector is counterweighted, and the observer is provided with a bite-board and a chin rest.

Moving targets which can be varied in velocity, acceleration, extent of displacement, as well as in intensity, form, and duration of exposure before and after movement are generated by an apparatus which projects 2-by-2-inch slides on a rotating mirror. The rotation of the mirror is controlled electromechanically in order to produce the desired pattern of movement, which is observed by the subject.

An electric signal proportional to the angular rotation of the mirror and hence to the angular position of the stimulus is obtained by mounting a pair of coils external to and above the mirror. A small third pickup coil attached to the back of the mirror extends up into the alternating magnetic field produced by the field coils. The field coils are driven at a resonant frequency of 8.5 kcy/sec by an audio generator. The output of the pickup coil is thus an amplitude-modulated signal which is calibrated in terms of the known limits of travel of the mirror.

The amplified d-c signal from the photomultiplier tube and the a-c signal from the pickup coil on the mirror are input signals to an electronic switch. By means of this switch both signals are displayed on an oscilloscope, and the display is recorded photographically by a camera with a Polaroid adapter.

Figure 2 shows a typical recording of the tracking motion of an observer's right eye and the associated movement of the stimulus. The point at which the "envelope" opens in the upper trace represents the beginning of movement

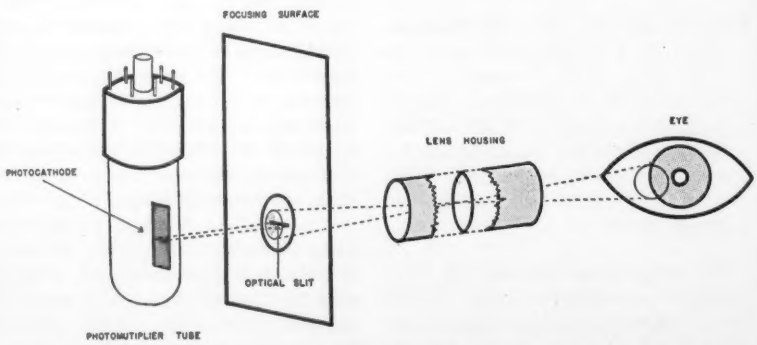


Fig. 1. The principle of measurement in schematic form. The lens casts an image of a portion of the iris and sclera on a focusing surface containing a slit. Behind the slit is the photocathode of a photomultiplier tube. As the eye moves laterally, more or less of the iris is imaged on the slit, and hence more or less total light strikes the photocathode. Variation in total energy thus can be correlated with eye position.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

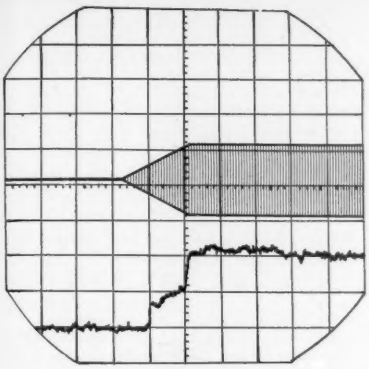


Fig. 2. Oscilloscopic record of stimulus movement (upper trace) and the corresponding tracking movement of the eye (lower trace). Velocity of stimulus movement constant at 21.5 deg/sec. Extent of movement, 8 deg, left to right. Horizontal sweep time, 200 msec/cm. Change in angular position of eye is linearly related to voltage change. Voltage scale, 5 volt/cm (vertical).

of the target, which consisted of a dark vertical hairline and which moved 8 deg from right to left at a constant velocity. The constant velocity is indicated by the linear sides of the envelope. Cessation of motion of the stimulus is indicated by the point where the sides of the envelope become parallel.

The eye-movement record (lower trace) in Fig. 2 shows a reaction time of approximately 160 msec and a pattern of an initial and final saccadic movement with a brief intermediate smooth pursuit movement of duration approximately 200 msec. A slight overshoot is evident for about 600 msec after cessation of the movement of the stimulus. When this record was made, the stimulus was visible in a fixed position both before and after movement. Eye fixations at these stages of the display are indicated by the horizontal components of the record at the beginning and the end of the eye-movement trace. The noise level in the record is a combination of electronic noise and physiological nystagmus.

From records such as that shown in Fig. 2, reaction time and rate characteristics of eye movement are determined easily, as well as lag-lead errors with respect to the stimulus at any point in time. Considering the flexibility of the stimulus-generating system described, it will now be possible to obtain systematic and extensive data on the eye as a tracking mechanism, and correlated with these data, the perceptual data for moving stimuli. Moreover, the principle of measurement used in conjunction with a miniaturized detector which can be worn by the observer without external support will make possible for the first time eye-movement measurement with free head movement. The miniaturization of the detector and the use of the present principle of measurement in recording vertical motions of the eye are currently being developed.

WILLIAM M. SMITH
Department of Psychology, Dartmouth College, Hanover, New Hampshire
PETER J. WARTER, JR.
Department of Electrical Engineering, Princeton University, Princeton, New Jersey

References and Notes

1. G. Westheimer, *A.M.A. Arch. Ophthalmol.* **52**, 932 (1954).
2. Research on design and development of this technique for measuring eye movements has been supported by the National Science Foundation. We acknowledge the valuable assistance rendered by Theodore Marton of Princeton University.
3. RCA 931-A or RCA 1P-21. The latter is a "selected" tube; for a given noise level it has greater sensitivity than the former.
4. Dumont model 185-A, modified to provide electronic regulation of the anode voltage supply within the switch.
5. A headpiece for each observer is made from fast-setting plaster bandage. The detector is attached to the headpiece by screws and a metal base imbedded in the plaster.

25 June 1959

Electrolyte-Solvent Interactions: Effect of Electrolytes on Vibrational Spectrum of Methanol

Abstract. The addition of quaternary ammonium halides to dilute solutions of methanol in benzene shifts the equilibrium

Associated MeOH ⇄ unassociated MeOH

to the left. For several tetrabutylammonium salts, the order of increasing effectiveness in causing the shift is: picrate <nitrate <bromide <chloride. The results provide evidence for the solvation of electrolytes by polar molecules.

There has been considerable interest in spectral studies of electrolyte-solvent interactions in recent years. Most of these have involved metallic ions and a study of their ultraviolet or visible spectra in various solvents. The results of these studies have been interpreted in terms of charge-transfer complexes.

Another question is whether the extent of electrolyte association—for example, ion-pair formation—affects these spectra. Quite recently Popov and Humphrey (*1*) have shown that when anion-cation interaction is purely electrostatic, as in the quaternary ammonium salts, the extent of ion-pair formation has no effect on the ultraviolet and visible spectra.

No corresponding work has been done in the infrared. In this region of vibrational spectra it is conceivable that the interaction of electrolytes with polar molecules would modify the spectra of the latter—for example, by solvation.

We report here what is, as far as we know, the first observation of such an interaction—the influence of electrolytes on the equilibrium between associated and nonassociated methanol when both are dissolved in benzene.

It is well known that the O–H stretching vibration for methanol occurs at 2.75 μ and that the (self)-association peak occurs at 3.0 μ in pure liquid methanol (*2*). In a moderately dilute solution ($>25 \times 10^{-3}M$) of methanol in a nonabsorbing, nonpolar solvent (benzene), both peaks are present, their intensity ratio depending on the total concentration. In a very dilute solution the associated peak is absent. A plot of absorbancy versus total concentration for both peaks is shown in Fig. 1. The addition of an electrolyte tends to enhance the associated peak at the expense of the nonassociated one. A plot of the concentration ratio of the two forms as a function of total concentration is shown for various concentrations (molar concentrations are used throughout this report) of the electrolyte — tetrabutylammonium bromide (Bu_4NBr). The cationic charge is buried in a paraffin ball in this salt, and in the environment most of the electrolyte exists in the form of electrostatically associated ion pairs and quadrupoles, with the free-ion concentration rather low. However, in spite of what are probably rather weak electrostatic ion-dipole interactions, the effect of the salt in enhancing the associated methanol concentration is considerable, increases in the two concentrations being roughly equal to each other.

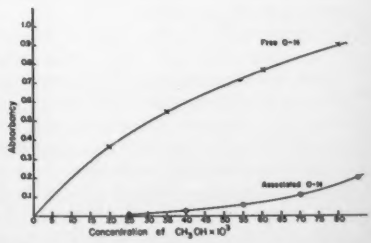


Fig. 1. Absorbancy of the free O–H (2.75 μ) and associated O–H (3.0 μ) peak as a function of total concentration in benzene.

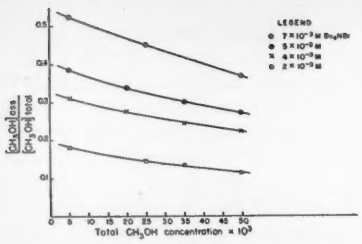


Fig. 2. Effect of various concentrations of tetrabutylammonium bromide on the equilibrium between free and associated methanol.

The effect of changing the anion is striking. Thus, for several tetrabutylammonium salts, the molar-extinction coefficient of associated methanol is as follows: for the picrate, ~ 0.0; for nitrate, 6.5; for bromide, 11.0; and for chloride, 12.0. Evidently the effectiveness of the anion in producing association increases in the same order as the anion charge density. This suggests that association in these cases is not self-association but ion-dipole association—that is, solvation.

JOSEPH BUFALINI
KURT H. STERN

Department of Chemistry,
University of Arkansas, Fayetteville

References

1. A. I. Popov and R. E. Humphrey, *J. Am. Chem. Soc.* **81**, 2043 (1959).
2. A. Stuart, *J. Chem. Phys.* **24**, 559 (1956).

27 July 1959

Occurrence of β-Aminoisobutyric Acid in Mytilus edulis

Abstract. β-Aminoisobutyric acid was isolated from organ extracts of *Mytilus edulis*. Ion-exchange resins and large-scale paper chromatography were used to isolate minute quantities of the compound. β-Aminoisobutyric acid was identified by paper chromatography in several solvents and by conversion to DNP-β-aminoisobutyric acid and subsequent chromatography of the derivative in several solvents.

β-Aminoisobutyric acid was first found in human urine by Crumpler *et al.* (*1*). They observed that some individuals excrete large amounts of this amino acid and that the excretion is an individual characteristic determined genetically. Several papers dealing with genetic factors involved in the excretion of this amino acid (*2*) have appeared since the paper by Crumpler *et al.* was published. Fink *et al.* found that β-aminoisobutyric acid is formed in the rat from thymine (*3*). Awapara and Shullenberger (*4*) observed that leukemic patients excrete large quantities of this acid only when given nitrogen mustard (methyl-bis[β-chloroethyl]amine hydrochloride) or thymine.

During an investigation of nitrogen metabolism in marine invertebrates, we observed that extracts of *Mytilus edulis* contain a compound with all the characteristics of β-aminoisobutyric acid as determined by paper chromatography. It was not an α-carboxyl amino acid, as was shown by treatment with copper carbonate (*5*). Extracts of *M. edulis* contain a large number of amino acids in large quantities. Proper identification by paper chromatography became difficult. The quantity of the unknown was not very large, and to isolate it in sufficient quantities for chemical analysis would be something of a tour de force. We have, however, isolated minute amounts of this compound and shown it to be chromatographically identical with β-aminoisobutyric acid.

For isolation, 100 gm of pooled organs of *Mytilus* were extracted with 80 percent ethanol (*6*). The extract was treated first with Amberlite CG-50 H^+ to remove basic compounds, then with Dowex 50, H^+, to remove all amino acids except taurine and other strongly acidic substances. The amino acids were displaced from the column with 4*N* NH_4OH. The effluent was evaporated under a vacuum. The residue was dissolved in 4 ml of water and decolorized with activated charcoal. To isolate the unknown from all other ninhydrin-reactive compounds, the solution was chromatographed on several sheets of filter paper. Known β-aminoisobutyric acid was chromatographed on the same paper to serve as a guide. The area corresponding to β-aminoisobutyric acid was cut and eluted. The eluate was chromatographed three more times with different solvents until only one ninhydrin-reactive substance was obtained. The R_f values of the unknown and known β-aminoisobutyric acid were identical in several solvents, and when mixed they could not be separated chromatographically (Table 1). A DNP derivative was prepared by the method of Sanger (*7*). Chromatography of the DNP derivative and of DNP-β-aminoisobutyric acid showed that they had identical R_f values in several solvents (Table 2). No separation occurred when they were mixed. From this evidence we concluded that the unknown was β-aminoisobutyric acid.

This compound is present in all parts of the animal. Analyses were carried out chromatographically, and the estimated concentrations are shown in Table 3. This compound appears to be present in other marine invertebrates, but its identity needs to be established with certainty. It is interesting that mammals and invertebrates catabolize thymine by a similar mechanism. β-Alanine also seems to be present in *Mytilus* and in several species of marine invertebrates studied (*8*). If these two amino acids are found in more species, there will be little doubt that thymine and uracil are catabolized to give rise to β-aminoisobutyric acid and β-alanine, respectively (*9*).

Table 1. R_f values of unknown and β-aminoisobutyric acid.

Solvent	R_f
Lutidine, water (62:38)	0.34
Phenol, water (72:28)	0.58
n-Butanol, acetic acid, water (120:30:50)	0.43
n-Butanol, formic acid, water (75:15:10)	0.48

Table 2. R_f values of DNP-β-aminoisobutyric acid and DNP-unknown.

Solvent	R_f
n-Butanol, ethanol, water (40:10:50)	0.71
n-Butanol, water (saturated)	0.53
n-Butanol, 0.1% NH_3 (saturated)	0.40
m-Cresol, 0.3% NH_3 (saturated)	0.74

Table 3. Concentration of β-aminoisobutyric acid in organs of *Mytilus edulis*.

Organ	Concentration (μmole/100 gm of fresh tissue)
Mantle	44
Gill	103
Viscera	62
Foot	93

J. AWAPARA
K. ALLEN

Biology Department,
Rice Institute, Houston, Texas

References and Notes

1. H. R. Crumpler, C. E. Dent, H. Harris, R. G. Westall, *Nature* **167**, 307 (1951).
2. R. Harris, *Ann. Eugenics* (*London*) **18**, 43 (1953); E. H. Sutton and S. G. Vandenberg, *Human Biol.* **25**, 53 (1955); E. H. Sutton and P. J. Clark, *Am. J. Phys. Anthropol.* **13**, 53 (1955); S. M. Gartler, *Am. J. Human Genet.* **8**, 120 (1956).
3. K. Fink, R. B. Henderson, R. M. Fink, *Proc. Soc. Exptl. Biol. Med.* **78**, 135 (1951); ———, *J. Biol. Chem.* **197**, 441 (1952); R. M. Fink, K. Fink, R. B. Henderson, *ibid.* **201**, 349 (1952); R. M. Fink, C. McGoughey, R. E. Cline, K. Fink, *ibid.* **218**, 1 (1956).
4. J. Awapara and C. C. Shullenberger, *Clin. Chim. Acta* **2**, 199 (1957).
5. H. R. Crumpler and C. E. Dent, *Nature* **164**, 441 (1949).
6. J. Awapara, *Arch. Biochem.* **19**, 172 (1948).
7. F. Sanger and E. O. P. Thompson, *Biochem. J.* **53**, 353 (1953).
8. J. W. Simpson, K. Allen, J. Awapara, *Biol. Bull.*, in press.
9. This work was supported by grants from the Robert A. Welch Foundation, Houston, Tex., and from the National Institutes of Health.

17 July 1959

Parasitic Relationship between Two Culturally Isolated and Unrelated Lichen Components

Abstract. The presence of numerous haustoria, with accompanying death of the algal cells, was noted in a mixed cuture of the fungal symbiont (mycobiont) of *Collema tenax* (Sw.) Ach., em. Degel. and *Trebouxia impressa* Ahm., the algal partner (phycobiont) of *Physcia stellaris* (L.) Nyl. The parasitic action was noted even on media which would optimally sustain the independent growth of the individual symbionts.

The nature of the lichen association is often a difficult one to define. Frequently described in textbooks as the perfect example of a symbiotic partnership, it is becoming increasingly evident (*1*) that, in many lichens, the relationship is not so idyllic. In species of *Collema*, a genus of lichen with *Nostoc* as the phycobiont, the fungal component does not form typical haustoria, but, rather, a loose association exists between the hyphae and the algal cells. It has been shown, however, that the previously isolated and cultivated mycobiont of *Collema tenax* has a lethal effect on its *Nostoc* partner if the two are grown together under cultural conditions (*2*). We thought it would be of interest to see whether this lethal action occurred with another type of lichen phycobiont—namely, *Trebouxia impressa*, a unicellular green alga earlier isolated from *Physcia stellaris* (*3*). The former lichen was collected from Knivsta, Sweden; the latter, from Bedford, Mass.

The medium used was that of Bristol (*4*), slightly modified, as follows: K_2HPO_4, 0.5 gm; $NaNO_3$, 0.5 gm; $MgSO_4 \cdot 7H_2O$, 0.15 gm; $CaCl \cdot 2H_2O$, 0.05 gm; NaCl, 0.05 gm; ferric citrate, 0.01 gm; citric acid, 0.01 gm; $Na_2MoO_4 \cdot 2H_2O$, 0.25 mg; agar, 15 gm; redistilled H_2O, 1000 ml. Comparative series of similar cultures were also performed. The first was with the addition of 20 gm of saccharose to the above medium, the second with addition of 20 gm of glucose, and the third, with addition of 20 gm of malt extract. The *p*H's of the media were about 7.5. Cultures were maintained in test tubes.

The alga, taken from a pure clonal culture, was inoculated as a thin line along the slanted agar surface. Ten days later, after visible growth of the alga, the fungus, taken from a pure polyspore culture, was inoculated in the middle of this algal string. Before inoculation, the fungus was washed in sterile water to eliminate, or at least make negligible, any accompanying transfer of nutrient material. Control sets of cultures were made with the phycobiont alone on all types of media utilized. The tubes were kept at 17°C at a light intensity of 200 lux and with a light duration of 16 hr/day. Illumination was provided by a ramp of varicolored fluorescent lamps (designed to simulate natural light), made at the Swedish factory of Philips. The cultures were examined after 3 months' growth.

Fig. 1. Empty cells of the alga *Trebouxia impressa*, phycobiont of the lichen *Physcia stellaris*, penetrated by hyphal branches of the fungal component of *Collema tenax*. Culture on Bristol's inorganic medium. (× 1200)

In the mixed cultures growing on inorganic medium, scattered spots of dead algal cells were noted, a condition which might have resulted from a lethal action (via some diffusible substance) of the mycobiont. If this was the case, however, the lethal effect was very weak and erratic, as evidenced by the small size and the isolated and unrelated nature of these necrotic spots. Microscopic examination of these spots showed many dead and empty algal cells, a large percentage of them being filled with fungal hyphae. Although the percentage was quite low, algal cells with a healthy appearance were seen, with penetrating fungal haustoria. The good growth of the mycobiont on this inorganic medium can only attest to its direct or indirect utilization of the algal cells for its organic substances. The algae in the control tubes of inorganic medium appeared healthy in all respects, both macroscopically and microscopically. The other cultures on nutrient media, although lacking visible necrotic zones (because of the rapid growth of the algae) did show, microscopically, the same numerous dead algal cells filled with hyphal branches. Here again, healthy-looking algal cells were seen with haustoria.

It is hoped that this experiment will provide further insight into the highly enigmatic problem of lichenization. It is through continued investigations on the independent symbionts that a clearer understanding of the composite plant will be obtained.

VERNON AHMADJIAN*
Department of Biology, Clark University, Worcester, Massachusetts
ELISABET HENRIKSSON
Institute of Physiological Botany, University of Uppsala, Uppsala, Sweden

References and Notes

1. A. Plessl, *Osterr. Botan. Z.* **96**, 145 (1949); G. Degelius, *Symbolae Botan. Upsalienses* **13**, 2 (1954); L. Geitler, *Osterr. Botan. Z.* **102**, 317 (1955); H. Schiman, *ibid.* **104**, 409 (1957); V. Ahmadjian, *Svensk Botan. Tidskr.* **53**, 71 (1959).
2. E. Henriksson, *Svensk Botan. Tidskr.* **52**, 391 (1958).
3. One of us (E. H.) was aided by a grant from the Swedish Natural Science Research council.
4. B. M. Bristol, *Ann. Botany (London)* **34**, 35 (1920).
* John G. Bergquist fellow of the American Scandinavian Foundation for 1958.

6 July 1959

Another Meteorite Crater Studied

A recent expedition from the American Meteorite Museum (January 1959) for the study of meteorite craters in Australia discovered a gross error in the reported size of the little Dalgaranga crater in Western Australia. In the literature this crater is credited with a diameter of 225 feet and a depth of 15 feet. Consequently, the museum expedition personnel (consisting of Mrs. H. H. Nininger, Allan O. Kelly, a geologist from Carlsbad, Calif., and myself) were

quite surprised to find that the crater has a diameter of only 70 feet and a depth of only 10½ feet.

The crater had been reported originally by E. S. Simpson in 1938. Simpson's report was based upon a description given him by a former manager of the Dalgaranga sheep station, who reported finding several meteorite fragments around the crater in 1923. Simpson did not go to see the crater. His erroneous report was the basis of the incorrect measurements which were incorporated in the recent British Museum Catalog of Meteorites and which have been given in numerous other publications.

A survey, including a description of the meteorite fragments that were recovered at the site during the recent visit to the crater, is being prepared by the museum.

H. H. NININGER
American Meteorite Museum, Sedona, Arizona

15 September 1959

Effect of Chlorine Dioxide on Lignin Content and Cellulose Digestibility of Forages

A significant negative correlation exists between the percentage of lignin in a forage and the digestibility of the dry matter and the crude fiber. Lignin is susceptible to decomposition by chlorine and its oxides. The removal of lignin from plant material by sodium chlorite in aqueous acid solutions is part of the procedure for the preparation of holocellulose. Holocelluloses prepared from wood have been found to have digestion coefficients of 80 to 90 (*1*), which are higher than those of cellulose in untreated wood. The treatment of forages to remove lignin should lead to an improved utilization of the fibrous constituents of forages. Various treatments of forages or low-grade feeds have been carried out with delignifying agents; an example is the work of Prianishnikov and Tomme (*2*). They treated straw with aqueous ClO_2 and then with aqueous sulfite; however, a loss in soluble constituents resulted, even though the digestibility of the crude fiber was increased. So far as we know, no observations on the effect of ClO_2 gas in the dry state on the digestibility of forage have been made.

Table 1. Lignin content and cellulose digestibility of forages treated with ClO_2 gas.

Treatment	Hygroscopic moisture (%)	Acid-insoluble lignin (%)	Digestion coefficient of cellulose
Orchard grass, flowering, treated in 10-gm lots			
No treatment	5.6	5.3	36.9
0.2 gm $NaClO_2$	6.2	5.3	39.2
2.4 gm $NaClO_2$	5.7	3.9	48.0
3.0 gm $NaClO_2$	6.2	3.6	46.3
Reed canary grass, late dough, sample previously extracted with benzene-alcohol, treated in 5-gm lots			
No treatment	5.2	5.5*	30.9
1.2 gm $NaClO_2$	6.2	3.7*	40.0
3.0 gm $NaClO_2$	7.2	2.0*	46.9
Wheat straw, treated in 8-gm lots			
No treatment		6.7	22.8
2.5 gm $NaClO_2$†		2.8	36.2
3.0 gm $NaClO_2$		3.9	24.0
3.2 gm $NaClO_2$		1.85	52.2

* Percentage of original grass. † Final aeration with vapor from ammonium carbonate solution.

Experiments were carried out on a laboratory scale to degrade the lignin without loss of soluble constituents of forage. Three forages were treated as follows: Air was bubbled through a solution of sodium chlorite, sodium acetate, and acetic anhydride and then passed through a glass tube containing 5 to 10 gm of finely ground roughage in an air-dry state for 4 to 24 hours. The sample, still apparently air-dry, had an acid odor which could be removed by exposure to air, by vacuum treatment, or by a short aeration with air containing ammonia. The product was analyzed for acid-insoluble lignin (*3*), and the digestion coefficient of its cellulose was determined by an artificial-rumen technique developed at the Pennsylvania Agricultural Experiment Station (*4*). The results appear in Table 1. The dry treatment of dried and ground grass and straw with ClO_2 resulted in a marked decrease in the acid-insoluble lignin content as determined by chemical analysis and in a significant increase in the digestibility of the cellulose as indicated by the artificial-rumen technique. The changes were related to the amount of sodium chlorite that was used (*5*).

J. T. SULLIVAN
Agricultural Research Service, U.S. Department of Agriculture, University Park, Pennsylvania
T. V. HERSHBERGER
Agricultural Experiment Station, University Park, Pennsylvania

References and Notes

1. W. Klauditz and M. Becker, *Holzforschung* **6**, 103 (1952); *Chem. Abstr.* **47**, abstr. 8927f (1953).
2. N. D. Prianishnikov and M. F. Tomme, *Biedermanns Zentr. B. Tierernähr.* **8**, 104 (1936).
3. J. T. Sullivan, *J. Animal Sci.*, in press.
4. T. V. Hershberger, T. A. Long, E. W. Hartsook, R. W. Swift, *ibid.* **18**, 770 (1959).
5. This report is contribution No. 173 of the U.S. Regional Pasture Research Laboratory, Crops Research Division, U.S. Agricultural Research Service, in cooperation with the 12 northeastern states and authorized for publication 10 July 1959, as paper No. 2385, Journal Series, Pennsylvania Agricultural Experiment Station.

15 July 1959

Sodium- and Potassium-Sensitive Glass Electrodes for Biological Use

Abstract. Continuous, accurate recording in circulating fluids from a sodium and a potassium electrode is described. The Na electrode is capable of discriminating $\triangle[Na^+]$ of less than 1 meq/lit. in 140 meq/lit., and the K electrode is capable of discriminating $\triangle[K^+]$ of less than 1 meq/lit. in the range of 1 to 10 meq/lit. with good reproducibility. The electrodes may be used singly or in pairs with a common reference calomel electrode for simultaneous monitoring of $\triangle[Na^+]$ and $\triangle[K^+]$ in mixed solutions. Problems of streaming potential dependent on flow rate and electrode shape, as well as transient K^+ response by the Na electrode, are discussed.

Eisenman, Rudin, and Casby have elegantly demonstrated that the ternary glass system, Na_2O-Al_2O_3-SiO_2, may be systematically varied to produce electrodes with high selective affinity for individual cations (*1*). They reported that NAS_{11-18} glass (Na_2O, 11 moles percent; Al_2O_3, 18 moles percent; SiO_2, 71 moles percent) was a particularly effective Na electrode and that effective K electrodes might also be prepared. Since then, working in cooperation with Eisenman *et al.*, we have been able to adapt NAS_{11-18} glass for practical use in biological systems by using metal-connected electrodes to overcome problems inherent in the nature of the glass (*2*). The present report (*3*) is concerned with the limits of precision of the Na electrode operating alone or paired in a two-electrode system with a K-selective electrode.

Tests of precision and reproducibility were carried out with a continuous flow system at constant rate. The electrode was mounted in a shielded cage, and the inflow and outflow tubes were interrupted by an air gap to reduce stray electrical interference. In such a system, solutions flowing past the electrode membrane can be changed only gradually and, theoretically, never completely. Pockets of solution in the line may also produce erratic mixing. The reproducibility of potentials is, nevertheless, limited only by the drift rate of the electrometer which, for short intervals, is negligible (Fig. 1*A*). Precision is limited mainly by the accuracy of the standards and the ± 20 μv noise level of the Cary electrometer (equivalent to less than 0.2 meq/lit. on a base of 140). Recovery of Na added to plasma can be equally good.

As in the case of the H^+ electrode the streaming potential of the Na^+ electrode is affected by flow rate, particularly in unbuffered solutions. The response is a function peculiar to each electrode but, in general, for electrodes with a capacity of less than 1 ml, the

response decreases as flow increases and becomes unimportant above approximately 35 ml/min. The curvature of the glass membrane is unimportant in inducing the effect, since potentials picked off 3-mm disks at various parts of an eccentric electrode did not differ. On the other hand, shape is important, as was determined in studies in which several shapes, from spherical to constricted tubes, were used. The effect of shape is shown in Fig. 1*B* (upper traces) which compares the fusiform electrode previously described (*2*) with a parallel-sided, simple tube constricted from 3 to approximately 1.5 mm diameter in the membrane area. In part, the observed reduction in streaming potential depends, of course, on volume. In part, however, it must also depend on the type of flow it produces or favors (for example, turbulent, laminar) since electrodes which are parallel-sided throughout and not constricted at the thinned-out membrane area seem to give even less response to varying flow than constricted tubes. Such electrodes are a trial to the glass blower but are much to be preferred.

Response time depends on the flow rate used during the change of solution. At a flow rate of 10 ml/min, the electrode responds fully in less than 10 seconds (Fig. 1*B*, lower trace). This time probably reflects the time taken to change the solution, and full change-over in such a flowing system is exponential in time. More detailed analyses of the electrode time constant are being undertaken with dip-type electrodes.

Two electrodes may be operated simultaneously, with two electrometers, one grounded and one isolated from ground. Both electrodes are placed in line with a single reference calomel electrode between them. The feasibility of this arrangement depends on the type of electrometer used. With Cary electrometers there is some beating due to asynchrony between the two vibrating reeds; this might be avoided by using a single reed driving a second slave reed. The beat is not objectionable, however, at amplifications of 100 mv or more, such as used in this work. Two Na electrodes can thus be used together to study, for example, arteriovenous differences. It is also possible to measure separately both the Na^+ and K^+ activities of an unknown mixture with the highly selective NAS_{11-18} electrode in conjunction with a K-preferring electrode, as predicted (*1*). Typical results are shown in Fig. 1*C* using the Na electrode together with a stable K glass prepared by us from an initial composition of Na_2CO_3 (45 moles percent), Al_2O_3 (4.5 moles percent), SiO_2 (47.3 moles percent), and CaO (3.2 moles percent). With a good

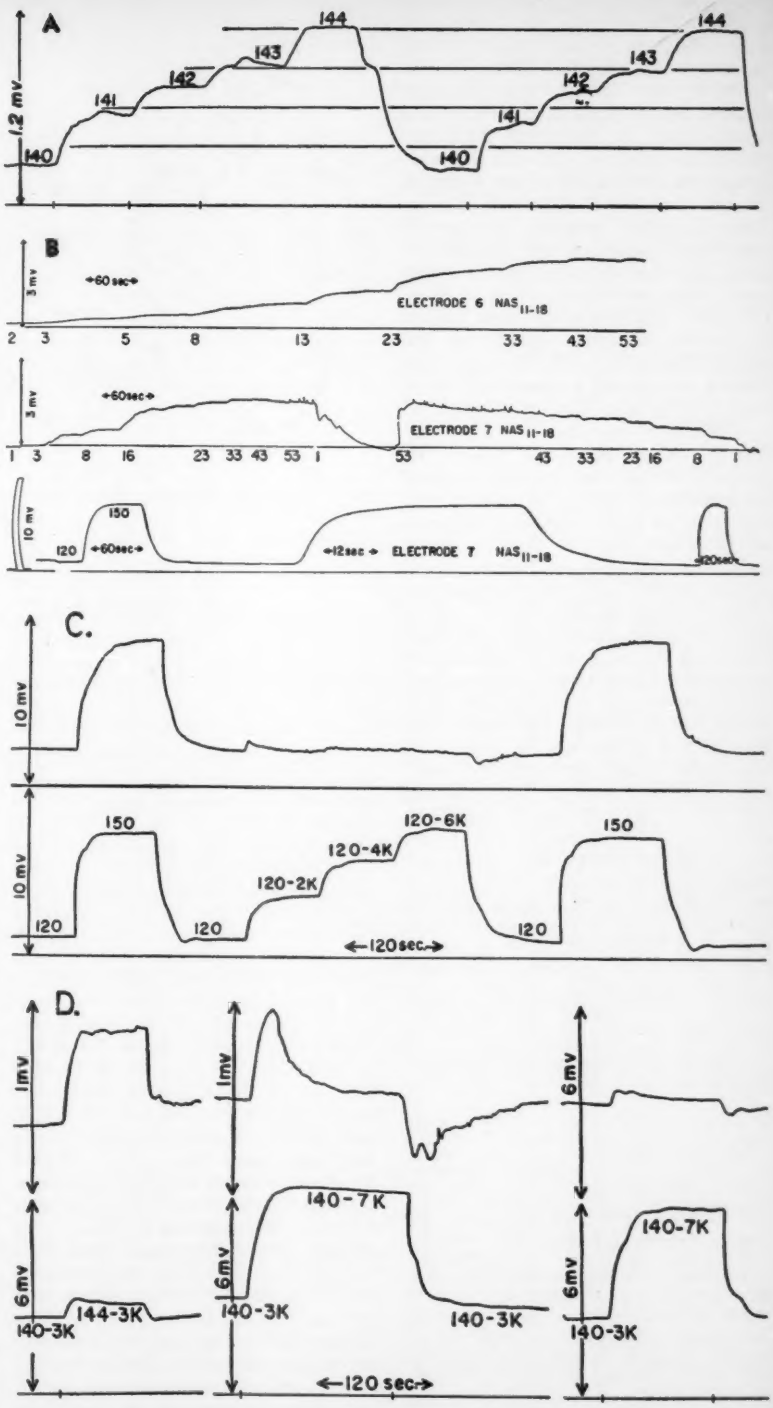


Fig. 1. (*A*) Response of an NAS_{11-18} electrode to changes in $[Na^+]$ between 140 and 144 meq/lit. (*B*) Changes in flow rate between 1 and 53 ml/min and electrode potential in pure NaCl with musiform electrode (top trace) or parallel-sided, constricted electrode (middle trace). Response time to changes in concentration (120 to 150 meq of NaCl per liter) at a flow rate of 10 ml/min (lower trace). (*C*) Simultaneous responses of Na electrode (upper trace) and K electrode (lower trace) to changes in $[Na^+]$ (120 to 150 meq/lit.) and $[K^+]$ (0 to 6 meq/lit.). (*D*) Simultaneous responses of Na electrode (upper trace) and K electrode (lower trace) to small changes in $[Na^+]$ (140 to 144 meq/lit.) and $[K^+]$ (3 to 7 meq/lit.) at selective amplification. Note the transient potential developed by the Na electrode on changing $[K^+]$ (middle pair).

K electrode in the pair, changes in Na^+ and K^+, as distinct from absolute values, can be monitored directly and continuously in biological fluids by taking advantage of their differing concentration ranges. Thus, for example, in the presence of a sodium concentration of 140 meq/lit., changes in potassium concentration between 1 and 10 meq/lit. can be accurately read with our electrode at a 6-mv full-scale amplification without change in the Na electrode equilibrium potential. Conversely, the K electrode responds only to large changes in Na at this amplification and background.

While it is true that a highly selective Na electrode is not affected by low K^+ activity, this statement should be modified by adding "at equilibrium." There is, in fact, a transient response to K^+ which may be as great as an equivalent Na^+ change, followed by a return to the basal electrode equilibrium potential in less than 1 minute (Fig. 1*D*). The response may be positive on addition of K^+ or negative on withdrawal. This transient cation potential, which has not previously been noted, is of considerable theoretical interest but should not be difficult to deal with in ordinary biological work.

SYDNEY M. FRIEDMAN
JAMES D. JAMIESON
MIYOSHI NAKASHIMA
CONSTANCE L. FRIEDMAN
Department of Anatomy, University of British Columbia, Vancouver, Canada

References and Notes

1. G. Eisenman, D. O. Rudin, J. U. Casby, *Science* **126**, 831 (1957).
2. S. M. Friedman, J. D. Jamieson, J. A. M. Hinke, C. L. Friedman, *Proc. Soc. Exptl. Biol. Med.* **99**, 727 (1958).
3. This work was supported by a grant from the Muscular Dystrophy Association of Canada.

15 July 1959

Bregmatic Bones in North American Lynx

Abstract. Anomalous bregmatic fontanelle bones were present in 279 of 1790 skulls of *Lynx rufus* examined, but with no apparent correlation with age, sex, or place of origin of the specimens. Examination of 472 skulls of *Lynx canadensis* disclosed only one possessing bregmatic bones.

Among the anomalous bones found in the mammalian skull is the fontanelle bone occurring in the bregmatic or anterior fontanelle at the junction of the coronal and sagittal sutures. In the 16th century this bone was noted in the human skull by Paracelsus, who named it the "ossiculum anti-epilepticum" from its supposed value as a cure for epilepsy. The presence of this bregmatic bone in various mammals was reported by Schultz (*1*), who found it quite common in some forms—for example, *Castor, Erethizon, Erinaceus,* and *Procyon cancrivorus.* However, among felids, Schultz found it in none of 62 specimens examined; he reported it as present in only one of 49 felids examined earlier by von Jhering.

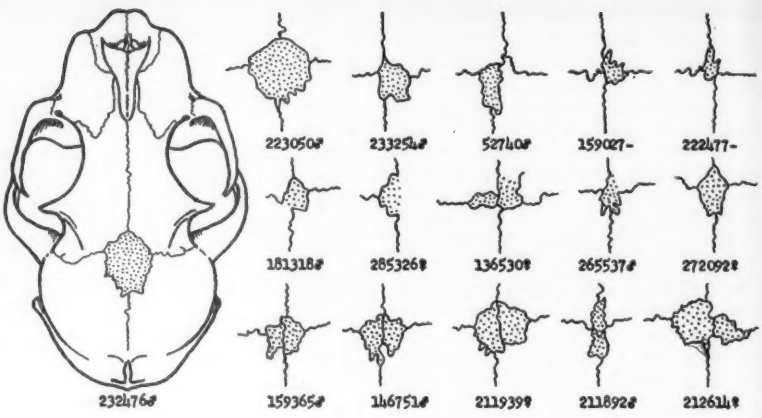


Fig. 1. Types of bregmatic bones observed in North American *Lynx* (No. 212614, *L. canadensis;* all others, *L. rufus*). All are similarly oriented and drawn to the same scale (about × ½).

In the course of examining a series of skulls of bobcats, *Lynx rufus,* from Oregon, bregmatic bones were found with surprising regularity—in 16.8 percent of 220 specimens. A further examination of all 1790 bobcat skulls in the U.S. National Museum (Biological Survey) collection disclosed bregmatic bones present as follows: in 141 of 957 adult males, in 116 of 653 adult females, in 17 of 155 adults of unknown sex, in 1 of 13 juvenile males, and in 4 of 12 juvenile females. Thus, bregmatic bones were present in 279 (15.5 percent) of the 1790 specimens examined. There was some geographic variation: the bone was present in 37.5 percent of 32 specimens from West Virginia and in 44.0 percent of 9 specimens from Mississippi, but in only 7.0 percent of 158 specimens from Texas and 14.6 percent of 123 specimens from Nevada. The bone was present in the southernmost of all specimens, a juvenile female from Amecameca, México, Mexico, but it was absent in all 11 specimens from British Columbia, New Brunswick, and Nova Scotia, as well as in 5 specimens from Alabama, 25 from Georgia, and 14 from South Dakota. It is probable that, as stated by Schultz, "it is never justifiable to ascribe any phylogenetic or atavistic significance" to these bones. They are present or absent with no regard to the age, sex, or geographic origin of the specimen.

These accessory, sutural bones, which form only in occasional cases, develop from one or more ossification centers in the membrane which closes the anterior fontanelle in fetal life. In the bobcat, they may be large or small in size, central or lateral in position, single or multiple in number, and they are almost always asymmetrical in shape. With advancing age, they coalesce with the frontal or parietal bones, and their original outlines may become obscured; this closure is only partially complete in many specimens. The variety of these bones is indicated in Fig. 1. In some forms (for example, *Homo*) it has been stated (*1, 2*) that they occur chiefly in males; this certainly is not the case in *Lynx rufus.*

Hall and Kelson (*3*), in their figures of skulls, indicate that this bone is present in *Lynx rufus* and absent in *L. canadensis.* In 472 specimens of the Canada lynx in the national collections, ranging from Alaska to Colorado and from Newfoundland to Oregon, readily identifiable bregmatic bones were present in only one specimen—an adult female (No. 212614) collected in 1916 in the Hoole Canyon of the Pelly River, Yukon Territory, Canada.

RICHARD H. MANVILLE
U.S. Fish and Wildlife Service, Washington, D.C.

References

1. A. H. Schultz, *J. Mammalogy* **4**, 65 (1923).
2. W. Gruber, *Arch. pathol. Anat. u. Physiol. Virchow's* **63**, 92 (1875).
3. E. R. Hall and K. R. Kelson, *The Mammals of North America* (Ronald, New York, 1959), vol. 2, pp. 967, 969.

16 July 1959

Horizontal Diffusion

Abstract. The neighbor diffusivity for pairs of diffused particles is determined from observations on drifts of various kinds of materials such as drift bottles in many parts of the ocean and a lake. Its values are expressed as the 4/3 power of separation of particles over a range from 10 to 10^5 cm.

A recent work by Joseph and Sendner on horizontal diffusion in the sea seems to give promise of an eventual resolution of the Fickian versus neighbor diffusivity problem (*1*). Among other things, it has caused us to reexamine our own work on the subject. The purpose of this note is essentially to extend the range in which the 4/3 power law appears to be valid.

It will suffice to consider only the one-dimensional aspect of diffusion. If $\nu(x)$ is the concentration of particles at x, there will be $\nu(x)dx$ particles between x *and* $x+dx$. By analogy to classical concentration, the neighbor concentration $q(l)$ is defined as the number $q(l)dl$ of pairs of particles whose separations are in the range l to $l+dl$. The Richardson diffusion equation

$$\frac{\partial q}{\partial t} = \frac{\partial}{\partial l}\left[F(l)\frac{\partial q}{\partial l}\right] \qquad (1)$$

is analogous to the classical Fickian equation since $F(l)$, the neighbor diffusivity, takes the place of the ordinary diffusivity K. Stommel postulated that the initial separation l_0 is large compared with $l_1 - l_0$, where l_1 is the separation after time T (*2*). With this restriction, he derived the relation

$$F\left[\frac{1}{2}(\overline{l_1 + l_0})\right] = \frac{\overline{(l_1 - l_0)^2}}{2T} \qquad (2)$$

where the bars indicate averages. Stommel checked the validity of this equation by using pieces of parsnip with spacings of the order of 25 to 200 cm (Richardson and Stommel, *3*) and dye spots with spacings 1000 to 10,000 cm and sheets of mimeograph paper with spacings 40 to 1000 cm (Stommel, *2*). These data are shown by crosses in Fig. 1. Later, Olson (*4*) showed that his drift card data (*5*) and Platania's (*6*) drift bottle data also seemed to satisfy Eq. 2 in spite of the severe deviation from the conditions imposed in deriving the equation. This may be seen in Fig. 1 where Platania's data are represented by a square and Olson's data by triangles.

Ichiye treated drift bottle data from Japanese waters in a somewhat similar manner (*7*). Since he was interested at that time in verifying an approximation occurring in one of his derivations, the data were not plotted as they are in our Fig. 1. By plotting these data in this manner, however, we find (see circles) that they are in excellent agreement (*8*). The line shown in Fig. 1 was determined by least squares for the condition that the slope is 4/3. It represents the equation

$$F(l) = 0.0246l^{4/3} \qquad (3)$$

where $l = \frac{1}{2}(l_1 + l_0)$.

For the data as a whole, the correlation coefficient $r = 0.993$. For Ichiye's data alone, $r = 0.992$. A least-squares fit for the data as a whole gives a slope of 1.29; for Ichiye's data, the slope is 1.37.

Figure 1 is remarkable in many respects. Included in it are observations on parsnips, dye spots, sheets of paper, drift cards, and drift bottles. The observations were made in the Atlantic and Pacific oceans, in the Mediterranean Sea, and in Lake Erie. Drift card and drift bottle data are notoriously inaccurate. Most of the points were obtained under conditions which nowhere met the requirements made by Stommel in his derivation of Eq. 2. Yet the correlation over a range from 10 to 10^5 cm is 0.993 (*9*).

F. C. W. Olson
U.S. Navy Mine Defense Laboratory, Panama City, Florida

Takashi Ichiye
Oceanographic Institute, Florida State University, Tallahassee

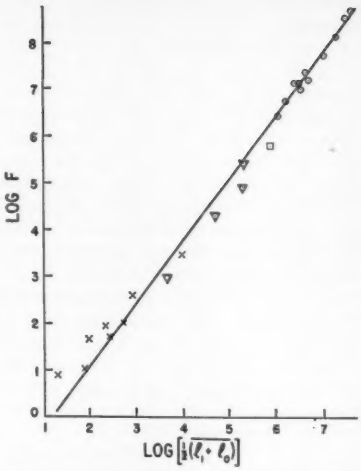


Fig. 1. Composite graph of data from Stommel (crosses), Olson (triangles), Platania (square), and Ichiye (circles). The line is a least-square fit of

$$\log F = \frac{4}{3}\log\left[\frac{1}{2}(\overline{l_1 + l_0})\right] + a,$$

where a was determined to be -1.609.

References and Notes

1. J. Joseph and H. Sendner, *Deut. hydrograph. Z.* **11**, 49 (1958).
2. H. Stommel, *J. Marine Research (Sears Foundation)* **8**, 199 (1949).
3. L. F. Richardson and H. Stommel. *J. Meteorol.* **5**, 238 (1948).
4. F. C. W. Olson, "An empirical expression for horizontal turbulence," *Florida State University Studies* **7**, 32 (1952).
5. ———, "The currents of western Lake Erie," dissertation, Ohio State Univ., (1950); *J. Marine Research (Sears Foundation)* **10**, 190 (1951).
6. G. Platania, "Experiments with drift bottles (second report)," *Rept. Danish Oceanog. Expeditions, 1908–1910, to the Mediterranean and Adjacent Seas* (1923), p. 3.
7. T. Ichiye, *Oceanog. Mag.* **3**, 83 (1951).
8. Actually l_1 was taken as the distance between recovery points of pairs of drift bottles thrown at the same station and l_0 was put to zero.
9. This report is contribution No. 119, Oceanographic Institute, Florida State University.

4 June 1959

Zinc-65 in Foods

Abstract. Small quantities of Zn^{65} have been found in a wide variety of foods obtained from the local markets serving Cincinnati, Ohio. The highest levels of radioactivity were observed in oysters harvested from Chesapeake Bay; however, none of the samples contained significant quantities of this radionuclide in terms of a potential radiological health hazard. In view of the widespread occurrence of Zn^{65} in foods, it has been postulated that this radionuclide has been dispersed by high-altitude fallout.

Recently Perkins and Nielsen (*1*) have reported the presence of Zn^{65} in produce from farms irrigated with water from the Columbia River and also in animals and people eating this farm produce. They state: ". . . Zn^{65} from nuclear tests has not been ob-

Table 1. Concentration of Zn^{65} in foods.

Sample	Date of sampling	Zn^{65} ($\mu\mu c$/kg)
Oysters (Chesapeake Bay)	Jan. 1959	178
Oysters (Chesapeake Bay)	Mar. 1958	124
Clams, hard-shelled (East Coast)	May 1958	40
Mixed Meats*	Sept. 1958	17
Mixed fresh leafy vegetables (washed)†	Aug. 1958	12
Mixed fresh root vegetables (washed)‡	Aug. 1958	10
Eggs	Aug. 1958	6
Mixed fresh legumes and corn (washed)§	Aug. 1958	4
Milk	Jan. 1959	4
Mixed fresh fruits (washed)‖	Aug. 1958	3

* Equal parts of chicken, lamb, beef, and pork; † equal parts of lettuce, cabbage, spinach, broccoli, celery, and cauliflower; ‡ equal parts of potatoes, sweet potatoes, carrots, beets, radishes, and turnips; § equal parts of shelled peas, string beans, shelled lima beans, and corn; ‖ equal parts of apples, grapes, grapefruit, oranges, peaches, plums, strawberries, and cantaloupe.

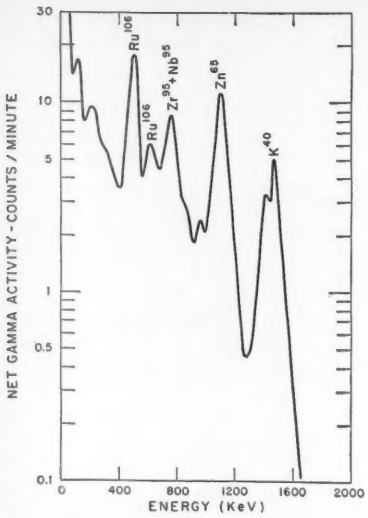


Fig. 1. Gamma spectrum of the ash of an oyster sample harvested from Chesapeake Bay.

served in foods raised in this country." Investigations made in our laboratory have revealed the presence of this radionuclide in a wide variety of foods of different origin, although at levels considerably lower than those observed in the samples collected downstream from the Hanford project.

A number of food samples purchased on the Cincinnati market have been analyzed for a variety of radionuclides, including Zn^{65}, during the past year. The gamma spectra of the ash of large samples of these foods, ranging up to 3 kg, have been determined with a heavily shielded 4- by 4-in. NaI crystal and a 100-channel pulse-height analyzer (*2*). With this instrumentation the efficiency of counting Zn^{65} was approximately 11 percent, and the sensitivity was of the order of 1 $\mu\mu$c in the ash.

The gamma spectrum of the ash of an oyster sample harvested from Chesapeake Bay is shown in Fig. 1; this curve reveals the presence of Zn^{65} in addition to some of the fission products and the naturally occurring K^{40}. The results of Zn^{65} analyses on a number of different food samples are summarized in Table 1, demonstrating the presence of this radionuclide in a wide variety of foods. The higher levels of Zn^{65} in oysters, as compared to other foods, is not unexpected in view of the findings of Chipman *et al.* (3), who demonstrated experimentally the capacity of this organism to concentrate Zn^{65} at levels many times higher than the level in the surrounding water.

The extent of nuclear operations, including the use of isotopes, in the Chesapeake Bay area seems entirely inadequate to account for the presence of the levels of Zn^{65} observed in oysters. Similarly, there are no obvious sources of the Zn^{65} found in the other foods; of these, some were grown in the Cincinnati area, while the rest were obtained from diverse parts of the United States. Therefore, it may be assumed that this radionuclide, which has been found in large amounts in samples taken near the Pacific proving grounds (*4*), must have been deposited on the East Coast and throughout the United States from high-altitude fallout.

The concentrations of Zn^{65} observed in these foods cannot be considered to constitute a radiological health hazard, since the maximum permissible concentration for this radionuclide is 6×10^6 $\mu\mu$c per liter of water or kilogram of food (wet weight) (*5*).

G. K. MURTHY
A. S. GOLDIN
J. E. CAMPBELL

Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio

References and Notes

1. R. W. Perkins and J. M. Nielsen, *Science* **129**, 94 (1959).
2. G. R. Hagee, A. S. Goldin, C. P. Straub, *J. Am. Water Works Assoc.* **50**, 621 (1958); we wish to thank Byron M. Branson for his assistance in determining the gamma spectra of the ashed samples.
3. W. A. Chipman, T. R. Rice, T. J. Price, *Fish. Bull. No. 135; U.S. Fish Wildlife Serv. Fishery Bull. No. 58*, pp. 279-292.
4. Y. Hiyama, paper No. P/1052, in *Peaceful Uses of Atomic Energy* (United Nations, New York, 1956), vol. 13, p. 368; A. D. Welander, *U.S. Atomic Energy Comm. Document No. UOFL-49* (1957).
5. "Standards for Protection Against Radiation," *Federal Register* **22**, title 10, part 20, 548 (1957).

2 July 1959

Subthreshold Retinal Integration Shown in Low Contrast Flicker Measurements

Abstract. Evidence of facilitation of response has been found in psychometrically determined critical fusion frequencies to flicker at low contrast. Spatial summation is denied by the distribution form of the data. Temporal summation within a determined time limit is supported. This may be mediated through association cells at the bipolar-ganglion synapse.

The use of low-contrast flicker measurement to assess retinal function was proposed in 1958 (*1*). Flicker refers to the perceptual response to a rapidly alternating dark and bright stimulus. In the present study (*2*) we alternated two nearly equally bright foveal stimuli in a circular area 1° in diameter on a 50° surround at 5 percent contrast above and below the 60 cd/m² background. Originally, for experimental convenience, the stimuli were presented in random order in two ranges, from 22 to 34 and from 30 to 46 per second.

The perceptual response fails when the rate increases across a threshold, called the critical flicker frequency. This visual response is analogous and may be identical to the scintillation found in a weakly irradiated phosphor. It is random in nature and may represent a chance distribution of the responses of individual foveal cones. Our results have been expressed in terms of the duration of half of the stimulus cycle, being therefore shorter as the rate of flicker increases. For example, 40 flickers per second equals a half cycle of 12.5 msec. Data are reported for each eye separately for 172 subjects for approximately 112 trials per eye, or a total of 38,324 trials. This volume of data is sufficient for discrimination between various distribution forms (*3*). The data were analyzed as probability functions of perception of the flicker against the temporal duration of the brighter half of the alternation (Fig. 1).

The two ranges show considerable difference in response, although the rates of alternation and all other conditions were the same where the ranges overlap. Attempts to fit these two curves with normal or Gaussian frequencies by the methods of probit analysis and least squares were unsuccessful (*4*). The best fitting normal distributions showed chi-squared equal to 11.23 and 84.75 for the seven centralmost points for the slower and faster ranges respectively. The probabilities of fit are interpreted as 8 percent and less than 0.0001 percent.

An attempt to fit the curves to log-normal functions indicated that the transformation log $(X-A)$ for X would be needed (*5*). The data for the slower range fit a log-normal distribution nicely, where $A = 0$, $X^2 = 2.91$, and $p = 82$ percent for the seven centralmost points. In the case of the faster range, the function can be described accurately only when $A = 11$ msec; then X^2 becomes 1.93 and $p = 92$ percent for the centralmost points. The differential area between the two curves (Fig. 1) is itself a log-normal curve, where $A = 0$ (Fig. 2).

In attempting to establish another relationship between the distributions for the slower and faster ranges, the slower range curve was expressed as a probability power function, such that $p^n = 1 - (1 - p)^n$. This function, shown where $n = 5$ (Fig. 2), fails to approach any chance of congruency with the faster range curve.

In discussing these results, we refer to Polyak's description of the neural structure of the retina (*6*). Polyak describes the cones, the bipolar cells, and the ganglion cells as the primary neural

chain. In order for the response of the photoreceptive cone to become an afferent nerve impulse, the response must pass both the cone-bipolar and the bipolar-ganglion synapse. Summation should occur through specialized bipolars (Polyak types "e" and "f") which extend their dendrites to several cones. This type of summation would be spatial, and stimulation of *any* cone might be transferred to a single ganglion cell. In this case, if we were to consider the slower range function as mediated by primary single cone chains, the multiple cone-bipolar responses should be expressed as the powers of the improbabilities, $(1-p)^n$, where n represents the number of cones so interrelated. Such an interpretation is denied by the data.

On the other hand, the effect of the association cells (Polyak type "l") could be one of facilitation at the bipolar-cone synapse, so that any response passing the cone-bipolar synapse would be more likely to pass the bipolar-ganglion synapse. The stimulus to the association cell, en route past the bipolar-ganglion synapse, could so affect the association cell as to cause it to reduce the synaptic resistances at other corresponding synapses. This effect would be limited in time and would fade out. The data indicate that the time of this temporal summation is near 11 msec for these specific experimental conditions.

Having allowed for the time interval, we find that the differential frequency curve for the facilitated function takes a log-normal form, where $A = 0$, as did the responses for the slower range.

A reason for the separation of the responses into two functions can be deduced from the nature of the two stimuli patterns. In both sets, time is a random variable within the range presented. The stimulus changes cross the threshold in either direction, from suprathreshold to threshold, and from subthreshold to threshold. The slower rates are more frequently above the threshold, and as such, serve to complete the neural discharges along the chain, thus decreasing any facilitation, since none is needed. On the other hand, the faster rates are more frequently below the threshold, thus increasing facilitation, and thereby increasing the probability of response.

In interpreting these findings in terms of visual behavior, we conclude that when the stimulus conditions approach threshold levels of intensity or extensity, the estimate of the threshold will be affected by summation, which may be temporal as well as spatial in nature. An uncontrolled criterion of response, and insufficient data, can serve to raise falsely the estimate of threshold, thus decreasing the opportunity to establish individual differences and hence decreasing the opportunity to determine the deleterious effects of dysfunction in pathology.

In the field of neuron theory, the results here presented provide interesting confirmation for the newer neuron doctrines described by Bullock (*7*).

R. H. PECKHAM
WILLIAM M. HART
Eye Research Foundation, Bethesda, Maryland

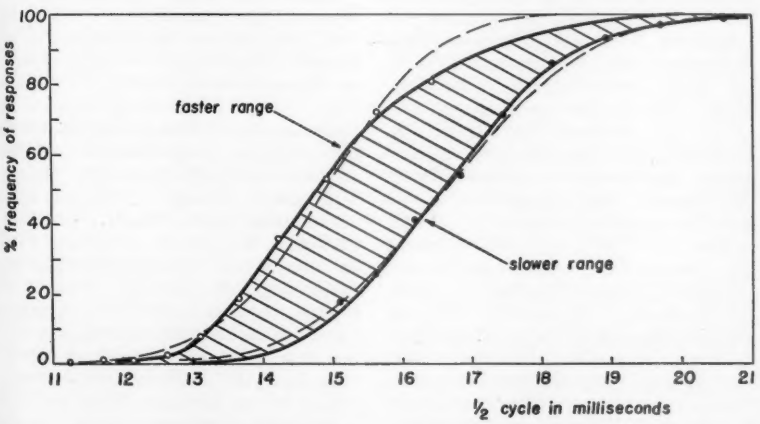


Fig. 1. Fitting of normal distributions to probability of response data summed for 38,324 trials on 344 eyes. The solid points represent the slower range, the open points the faster range. The broken lines are normal (Gaussian) curves fitted by the method of least squares. The heavy solid curves are log $(X-A)$ normal curves, which fit better. For the slower range the factor $A = 0$; for the faster range, $A = 11$ msec. The shaded area indicates a differential enhancement of the faster range responses over those of the slower range.

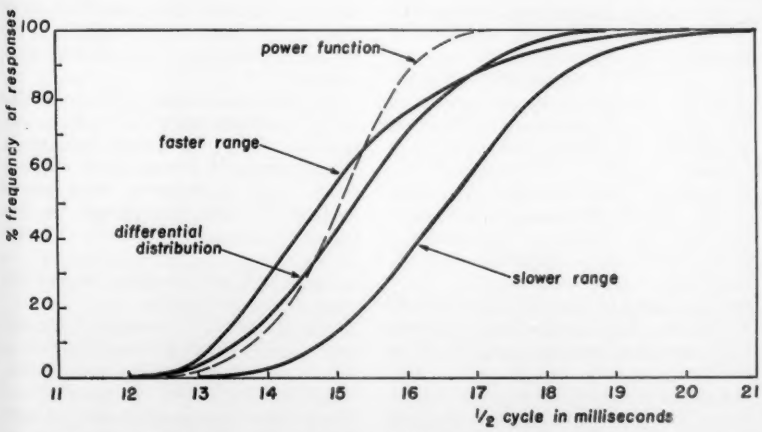


Fig. 2. Three retinal functions are represented by these distribution curves. The slower and faster range curves are traced from Fig. 1. The power function (broken line) represents the slower range curve raised to the power of $n = 5$ in the transformation $p_n = 1-(1-p)^n$. This represents spatial summation, but it cannot fit the faster range curve for any value of n. The differential distribution of the shaded area in Fig. 1 fits a log $(X-A)$ distribution where $A = 0$ and may represent the result of temporal summation.

References and Notes

1. R. H. Peckham and W. M. Hart, *A.M.A. Arch. Ophthalmol.* **60**, 461 (1958).
2. This work was done under contract Nonr-2750(00) between the Eye Research Foundation and the Office of Naval Research.
3. H. R. Blackwell, *J. Opt. Soc. Am.* **43**, 456 (1953).
4. D. J. Finney, *Probit Analysis* (Cambridge Univ. Press, Cambridge, 1947).
5. H. Cramer, *The Elements of Probability Theory* (Wiley, New York, 1955), p. 118.
6. S. Polyak, *The Vertebrate Visual System* (Univ. of Chicago Press, Chicago, 1957), Fig. 179.
7. T. H. Bullock, *Science* **129**, 997 (1959).

22 April 1959

Association Affairs

Programs Planned for the AAAS Chicago Meeting

Section and society programs in the biological sciences and agriculture to be presented at the Chicago meeting are given here. Programs in mathematics, physics, chemistry, astronomy, and geology and geography have been previously announced [*Science* **130**, 1196 (30 Oct. 1959)], except the AGU-IGY symposium which follows.

Physical Sciences (continued)

Two-session symposium: "Upper Atmosphere—Solar Relations"; joint program of the American Geophysical Union and the U.S. National Committee for IGY of the National Academy of Sciences–National Research Council, cosponsored by the American Meteorological Society; arranged by Stanley Ruttenberg, National Academy of Sciences. Part I, John A. Simpson, Enrico Fermi Institute for Nuclear Studies, University of Chicago, presiding. Papers will be presented on physics and radiation of the solar atmosphere (R. Grant Athay, High Altitude Observatory, University of Colorado); physics of the sun-earth space (Eugene Parker, Enrico Fermi Institute for Nuclear Physics, University of Chicago); motions in the magnetosphere of the earth (Thomas Gold, Department of Astronomy, Cornell University); non-relativistic protons from solar flares (John R. Winckler, University of Minnesota).

Part II, John R. Winckler, presiding. Papers will be presented on preliminary results from satellite Explorer VI: ionospheric physics (Robert A. Helliwell, Stanford University); preliminary results from satellite Explorer VI: cosmic rays (John A. Simpson, University of Chicago); temperature and density of interplanetary gas near the earth (Joseph W. Chamberlain, Yerkes Observatory, University of Chicago); trapped energetic particles and their geophysical consequences (Robert A. Jastrow, National Aeronautics and Space Administration).

Biological Sciences

· *Section F.* Two-session symposium, jointly with Section G–Botanical Sciences: Some Unsolved Problems in Biology, 1959; 28 Dec. Part I: "Organization of the Cell," cosponsored by the American Society of Zoologists and the Botanical Society of America; arranged by Norman G. Anderson, Oak Ridge National Laboratory, with Karl M. Wilbur, Duke University, presiding. Papers will be presented on nuclear-cytoplasmic interrelations (David M. Prescott, Oak Ridge National Laboratory); biochemical machines (David M. Prescott); and substructures of the cell (Norman G. Anderson).

Part II: "The Cell in Development and Inheritance," cosponsored by the American Society of Zoologists, the Botanical Society of America, and the Genetics Society of America; arranged by Barry Commoner, Washington University, with Frits W. Went, Missouri Botanical Garden, presiding. Papers will be presented on the role of the nucleus in embryonic differentiation (R. W. Briggs, Indiana University); paramutation and chromosome organization (R. A. Brink, University of Wisconsin); cytoplasmic inheritance (David A. Nanney, University of Illinois); the biochemistry of inheritance (Barry Commoner).

Two-session symposium, jointly with the Division of Biological and Medical Research, Argonne National Laboratory, and the U.S. Atomic Energy Commission; cosponsored by the American Society of Zoologists and the Electron Microscope Society of America; "The Impact of Electron Microscopy on Biology"; 29 Dec.; arranged by a committee of the Division of Biological and Medical Research, Argonne National Laboratory, consisting of B. R. Nebel, F. Wassermann, and E. L. Powers (chairman). Part I, Theodore N. Tahmisian, Argonne National Laboratory, presiding. Introduction (F. Wassermann); papers on the morphology and possible functions of some of the components of the cytoplasm (Albert J. Dalton, National Cancer Institute); from DNA to chromosomes (Hans Ris, University of Wisconsin); electron microscopic evidence of cellular activity (Sanford L. Palay, National Institute of Neurological Diseases and Blindness).

Part II, L. Evans Roth, Argonne National Laboratory, presiding. Papers will be presented on recent evidence on the structure and development of organelle systems and its importance to concepts of biological organization (Charles F. Ehret, Argonne National Laboratory): correlation of ultra-structure and function in nerve (H. Fernandez-Moran, Massachusetts General Hospital); cancer and viruses: past, present and future in the light of electron microscope studies (Leon Dmochowski, M. D. Anderson Hospital and Tumor Institute, Houston, Tex.); summary and outlook (Paul Weiss, Rockefeller Institute).

There will be five sessions of contributed papers. Session I: "Cell Studies"; cosponsored by the Society of General Physiologists; 27 Dec.; George A. Edwards, New York State Department of Health, presiding. Session II: "Developmental Biology and Morphology"; 27 Dec.; Ray Watterson, Northwestern University, presiding. Session III: "Endocrinology"; 30 Dec.; Raymond Breneman, Indiana University, presiding. Session IV, cosponsored by the Society of General Physiologists: "Physiology I"; 30 Dec.; Austin M. Brues, Argonne National Laboratory, presiding. Session V, cosponsored by the Society of General Physiologists: "Physiology II"; 30 Dec.; Ira G. Wool, University of Chicago, presiding.

Zoologists' dinner and vice-presidential address of Section F, cosponsored by the Society of Systematic Zoology: "Current Changes in the Environment of Zoological Research," by Herbert Friedmann, Smithsonian Institution; 29 Dec.; Karl M. Wilbur, Duke University, presiding.

There will be a biologists' smoker, 29 Dec., jointly sponsored by AAAS Sections F–Zoological Sciences and G–Botanical Sciences, and all biological societies.

Society of Systematic Zoology. The Society of Systematic Zoology is a cosponsor of the two-session symposium, "Speciation and Raciation in Cavernicoles," with the National Speleological Society, 28 Dec. The details can be found in *Science* [**130**, 1198 (30 Oct. 1959)].

There will be a session for contributed papers on 29 Dec.

Symposium: "Invertebrate Classification"; 29 Dec.; Libbie H. Hyman, American Museum of Natural History, presiding. Papers will be presented on the systematics and phylogeny of Protozoa (John O. Corliss, University of Illinois); the origin and phylogeny of the coelenterates (Cadet Hand, University of California); the functions and limitations of classification (R. E. Blackwelder, Southern Illinois University).

Chicago Academy of Sciences. Four-session symposium: "The Physiology of Reproduction in Birds"; 28 and 29 Dec.; at the Chicago Academy of Sciences, 2001 N. Clark St.; arranged by Richard A. Edgren, G. D. Searle & Company. Part I; R. A. Edgren, presiding. Introductory remarks, by R. A. Edgren; papers will be presented on the role of light and darkness in the regulation of reproductive cycles in birds (Albert Wolfson, Northwestern University); brain-gonadotrophin relationships in the hen (C. L. Ralph, University of Pittsburgh); endocrine control of avian ovaries (A. V. Nalbandov, University of Illinois); steroidal block of ovulation in the laying hen (T. W. Harris, G. D. Searle & Company).

Part II; Franklin C. McLean, University of Chicago, presiding. Papers will be presented on endocrine activities of the hypophysis and gonads of birds during prehatching stages (R. L. Watterson, Northwestern University); steroids and sex differentiation in the fowl (G. Pincus and T. F. Hopkins, Worcester Foundation for Experimental Biology); effects of steroidal hormones on differentiation and growth of the bursa fabricii (R. K. Meyer, M. A. Rao, and R. L. Aspinall, University of Wisconsin); the development of the avian female genital tract under different environmental conditions (A. van Tienhoven, Cornell University); the endocrine control of sex accessory growth and function in male birds (F. K. Hilton, University of Louisville).

Part III; W. J. Beecher, Chicago Academy of Sciences, presiding. Papers on hormonal effects on plasma lipids (and atherosclerosis) (Ruth Pick, Michael Reese Hospital); structure-active relationships in the steroid control of blood lipids in chicks (D. L. Cook and R. A. Edgren, G. D. Searle & Company); calcium metabolism and medullary bone formation (F. C. McLean, University of Chicago, and M. R. Urist, University of California at Los Angeles); secondary sexual characteristics and mating behavior in birds (W. J. Beecher).

Part IV; Albert Wolfson, Northwestern University, presiding. Papers on psychophysiological factors and social behavior related to sexual behavior (A. M. Guhl, Kansas State College); hormonal relations in incubation behavior of birds (D. S. Lehrman, Rutgers University).

American Society of Naturalists. Four-session symposium, cosponsored by the Ecological Society of America and the American Society of Limnology and Oceanography: "Interactions in Nature: a Symposium on Modern Ecology"; 27 and 28 Dec.; arranged by Arthur D. Hasler, University of Wisconsin. Part I: "Population Ecology." Papers: presidential address of the American Society of Naturalists; the place of ecology among the sciences (Paul B. Sears, Yale University); interactions in insect populations (Thomas Burnett, Entomology Laboratory, Ontario). Discussant: Thomas Park (University of Chicago).

Part II: "The Conversion of Energy." Papers will be presented on efficiency in ecological steady states (L. Basil Slobodkin, University of Michigan); productivity and the flow of energy in communities (Howard T. Odum, University of Texas). Discussant: George L. Clarke (Harvard University).

Part III: "The Nature of Adaptation in Plants." Papers will be presented on biochemistry of adaptation to environment (Edwin B. Kurtz, Jr., University of Arizona); ecotypes and community function (Calvin McMillan, University of Texas). Discussant: John T. Curtis (University of Wisconsin).

Part IV: "Ecology of Behavior." Papers on spatial orientation in animal behavior (Talbot H. Waterman, Yale University); the ethological approach in animal ecology (William S. Hoar, University of British Columbia). Discussant: Theodore Bullock (University of California at Los Angeles).

Beta Beta Beta Biological Society. Biennial business meeting; 28 Dec.; George H. Mickey, Louisiana State University, presiding.

Luncheon and address; "The Genetic Basis of Human Racial Differences," by H. Bentley Glass (Johns Hopkins University); 28 Dec.; George H. Mickey, presiding.

Ecological Society of America. There will be three sessions of contributed papers. Session I: "Animal Ecology"; 28 Dec. Session II: "Plant Ecology"; 28 Dec.; Alton A. Lindsey, Purdue University, presiding. Session III: "General Ecology"; 29 Dec.; Paul B. Sears, Yale University, presiding.

Two-session symposium, cosponsored by Sections E–Geology and Geography, F–Zoological Sciences, and G–Botanical Sciences: "Sand Dune Systems: Physical and Biological Aspects of Their Development"; arranged by Jerry Olson, Oak Ridge National Laboratory; 30 Dec. Part I: "Origin of Dune Landscapes"; Jerry Olson, presiding. Papers will be presented on Bermuda's fossil sand dunes and soils (J. Harlen Bretz, University of Chicago); factors controlling dune landforms (H. T. U. Smith, University of Massachusetts); the sand dune cycle and soil formation (David Simonett, University of Kansas); some Arctic dunes and their vegetation (Robert S. Sigafoos, U.S. Geological Survey); rates of succession on Florida sand dunes (Albert M. Laessle, University of Florida); vegetation dune formation along the Pacific Coast (William S. Cooper, Boulder, Colorado).

Part II: "Organization of Dune Communities"; Charles E. Olmsted, University of Chicago, presiding. Papers will be presented on structural and developmental patterns of some dune-building grass communities (Charles C. Laing, University of Nebraska); gradient analysis and experimentation on maritime dunes (William E. Martin, University of Minnesota); experiments on seed germination of dune plants (William Gillis, Michigan State University); diversity of dune ecosystems (Jerry Olson); discussion (Howard T. Odum, University of Texas).

Botanical Sciences

American Society of Plant Taxonomists. There will be two sessions of contributed papers; 28 and 29 Dec. Session I; William C. Steere, New York Botanical Garden, presiding. Session II; A. C. Smith, Smithsonian Institution, presiding.

Annual business meeting; 29 Dec. It will be followed by an informal discussion of herbarium curators.

Botanists' dinner and vice presidential address of Section G. Joint dinner of the American Society of Plant Taxonomists and Section G–Botanical Sciences. The speakers will be William C. Steere, New York Botanical Garden, and president, American Society of Plant Taxonomists, and Frits W. Went, Missouri Botanical Garden and vice president for Section G.

Mycological Society of America. Two-session symposium: "Classification of Fungus Groups of Debatable Affinity"; 30 Dec.; arranged by Donald P. Rogers, University of Illinois. Part I; C. J. Alexopoulos, State University of Iowa, presiding. Papers will be presented on relationships of the Actinomycetales (Clifford W. Hesseltine, U.S. Department of Agriculture, Peoria, Ill.); the systematic position of the myxomycetes (G. W. Martin, State University of Iowa); relationships and diagnostic criteria in the Synchytriaceae (John S. Karling, Purdue University); taxonomic position of the Eccrinales and related fungi (Robert W. Lichtwardt, University of Kansas).

Part II; G. W. Martin, State University of Iowa, presiding. Papers will be presented on phylogeny and classification of the Pyrenomycetes (Roy F. Cain, University of Toronto); phylogeny of the rust fungi (John W. Baxter, University of Wisconsin); taxonomic position of the Gasteromycetes in relation to the Agaricales (Alexander H. Smith, University of Michigan).

Agriculture

Section O. Five-session symposium, cosponsored by Section F–Zoological

Sciences, Section G–Botanical Sciences, Section N–Medical Sciences, Section Nd–Dentistry, Botanical Society of America, American Society of Agronomy, Gamma Sigma Delta, Society of American Foresters, Genetics Society of America, American Society of Animal Production, American Society for Horticultural Science, American Dairy Science Association, American Institute of Biological Sciences, International Association of Milk and Food Sanitarians, Poultry Science Association, American Genetic Association, American Society of Zoologists, Soil Science Society of America, and Crop Science Society of America: "Germ Plasm Resources in Agriculture: Development and Protection"; 28, 29, and 30 Dec.; arranged by R. E. Hodgson, U.S. Department of Agriculture, Beltsville, Md. Part I, "Origin of Germ Plasm"; C. O. Erlanson, U.S. Department of Agriculture, Beltsville, Md., presiding. Papers will be presented on geographic origin of plants useful to agriculture (J. R. Harlan, U.S. Department of Agriculture and Oklahoma State University); origin of animal germ plasm presently used in North America (H. H. Stonaker, Colorado State University); untapped sources of animal germ plasm (R. W. Phillips, U.S. Department of Agriculture, Washington, D.C.). The discussion leader will be Henry A. Wallace, South Salem, N.Y., former Vice President of the United States, Secretary of Agriculture and Secretary of Commerce.

Part II, "Need for and Utilization of Additional Sources of Germ Plasm"; H. J. Sloan, Agricultural Experiment Station, St. Paul, Minnesota, presiding. Papers will be presented on horticultural crops (F. P. Cullinan, U.S. Department of Agriculture, Beltsville, Md.); field crops (M. G. Weiss, U.S. Department of Agriculture, Beltsville); small farm animals (A. W. Nordskog, Iowa State College); large farm animals (J. L. Lush, Iowa State College). Discussant: H. A. Rodenhiser (U.S. Department of Agriculture, Washington, D.C.)

Part III, "Developmental Programs in Crops and Livestock"; E. J. Warwick, U.S. Department of Agriculture, Beltsville, Md., presiding. Papers will be presented on use of diverse germ plasm in crop improvement (Herman J. Gorz, University of Nebraska, and W. K. Smith, University of Wisconsin); effectiveness of selection for animal improvement (Gordon Dickerson, Kimber Farms, Inc., Niles, California); use of hybrid vigor in plant improvement (G. W. Burton, Coastal Plain Experiment Station, Tifton, Georgia, and G. F. Sprague, U.S. Department of Agriculture, Beltsville, Md.; extent and usefulness of hybrid vigor in animal improvement (L. N. Hazel, Iowa State College); performance testing in livestock (C. E. Terrill, E. J. Warwick, N. D. Bayley, W. A. Craft, and P. B. Zumbro, U.S. Department of Agriculture). Discussant: R. E. Comstock (University of Minnesota).

Part IV, "New Approaches to Plant and Animal Improvement"; A. E. Bell, Purdue University, presiding. Papers will be presented on contributions of laboratory animals to research in livestock improvement (A. B. Chapman, University of Wisconsin); immunogenetics and its application to livestock improvement (M. R. Irwin, University of Wisconsin); using germ plasm for new products (Quentin Jones, U.S. Department of Agriculture, Beltsville, Md., and Ivan Wolf, U.S. Department of Agriculture, Peoria, Ill.; irradiation and plant improvement (R. S. Caldecott, University of Minnesota); possibilities for genetic improvement of useful insects (Reece I. Sailer, U.S. Department of Agriculture, Beltsville, Md.). Discussant: W. V. Lambert (University of Nebraska).

Part V, "Perpetuation and Protection of Breeding Stocks"; Roy Magruder, U.S. Department of Agriculture, Washington, D.C., presiding. Papers will be presented on perpetuation and protection of germ plasm as seeds (Edwin James, U.S. Department of Agriculture, Fort Collins, Colo.); perpetuation and protection of germ plasm as vegetative stock (Russell E. Larson, Pennsylvania State University); preservation of breeding stocks through semen storage (N. L. Van Demark, University of Illinois); identification and elimination of defects in animals (F. B. Hutt, Cornell University). Discussion will be presented by T. C. Byerly, U.S. Department of Agriculture, Washington, D.C.

There will be two biological papers given at the AAAS General Symposium. On 26 Dec., Sidney W. Fox (Florida State University) will speak on "How Did Life Begin?" and on 27 Dec., Wendell M. Stanley (University of California) will speak on "Genes, Viruses, and Cancer."

The AAAS Popular Lecture will be "The World into Which Darwin Led Us," by George Gaylord Simpson, Museum of Comparative Zoology, Harvard University, with Chauncey D. Leake, Ohio State University and President Elect of the AAAS, presiding.

Many biologists will be interested in the programs of Sections I–Psychology, N–Medical Sciences, American Physiological Society, and American Psychiatric Association which will appear in a later issue.

Meetings

Mechanisms Involved in Conception

The ever-increasing multiplication of the human species has ceased to be an issue which the more complacent among us were wont to regard as a scare that had been needlessly generated by overenthusiastic neo-Malthusians. The pendulum has swung the other way. Everywhere we now find responsible people agreeing that sharp decreases in mortality rates, with corresponding increases in rates of population growth —both resulting from the widespread application of modern medical knowledge—are now threatening to nullify many carefully planned efforts to speed up social and economic progress in the underdeveloped areas of the world, and by so doing to help frustrate the wave of nation building which is now spreading across the globe. At the same time there is a general sense that the miracle pill which was going to prevent all this from happening is as far beyond the reach of the bulk of humanity as is space travel. As conviction grows that this is so, and with the realization of the political implications of the continuing disparity between rates of capital development and of population growth, there has been a widespread call for a realistic assessment of what we know about the processes of reproduction, and about the ways in which they can be controlled. To fill this need the Population Council and the Planned Parenthood Federation of America recently convened, at West Point, New York, a conference under the general title "Physiological Mechanisms Concerned with Conception," to which participants were invited from far and wide, including countries as distant as India, Japan, and Australia.

The preparation of the conference was entrusted to a central committee under the joint chairmanship of Carl G. Hartman and Warren O. Nelson, as well as to the chairmen of the six sections into which the subject matter of the conference was subdivided and to each of which about 12 members of the conference were assigned. The sectional agenda were carefully prepared over a period of months, through correspondence between the participants, and were then discussed in detail during the first 2 days of the meeting. On the following 3 days the results of these sectional deliberations were presented for further discussion before 6 plenary sessions, which were attended not only by the members of the separate sections but also by about twice as many other interested scientists. The proceedings

of all these meetings are now being assembled for publication by the sectional chairmen, under the general editorship of Warren Nelson.

The topics assigned to the separate groups were spermatogenesis; physiology of the male accessory organs; oögenesis and ovulation; sperm physiology and sperm migration; fertilization and implantation mechanisms; and immunological phenomena. Observations which had never been reported before cropped up in every section, but the sense of novelty which the conference as a whole generated derived mainly from the fact that the findings of various fields of study were being reassembled in a new and common framework, within which their relevance to each other could be assessed.

Unlike discussion in the physical sciences, it is often difficult to separate fundamental from applied science in fields of biological or medical inquiry. In the case of the physical sciences, for example, high-energy particles were being studied as matters of basic scientific interest long before anyone thought of applying their properties to explosive or controlled reactions. Even the practical uses of substances of such apparently obvious usefulness as Polythene or the Silicones remained obscure for what today appears a surprising length of time. But behind most pieces of fundamental biological research there always seem to lie urgent and obvious human problems. For example, antibiotics, viruses, and hormones are all subjects of basic research, but at every point they also relate, and are applied, to practical issues. Again, the mechanisms which underlie immunological reactions constitute a fascinating field of fundamental research, but there is no delay between their elucidation and the consideration of their relevance to the problems of transplanting the tissues of different individuals, as, most simply, in the practice of blood transfusion. So it was inevitable that a conference which was designed to focus attention on physiological mechanisms in reproduction should become concerned not only with understanding such mechanisms but also with controlling them.

Spermatogenesis

Among the more absorbing of the fundamental issues which were debated by group 1, which dealt with spermatogenesis, were the different stages in the transformation of spermatogonia into spermatozoa. It has always been recognized that the constellation of cell types seen at any given moment in a single cross section of a seminiferous tubule of a rat testis can be classified in different categories. What has now been done is to show that different steps in the differentiation of the spermatid are always temporally associated with the same phases in the process of multiplication and maturation of the spermatogonia up to the moment of the reduction division. The demonstration of this orderly procession has proved of great value in determining those stages of spermatogenesis in the rat which are normally marked by the highest incidence of cell death, and in studies with radioactive (tritiated) thymidine which were designed to determine the duration of the separate phases, and thus of the whole cycle of change in the seminiferous epithelium. In the course of these studies, which provide the best evidence we have, even if it is not yet decisive, of how long it takes a "stem-cell" spermatogonium to produce a spermatozoon in the rat (48 days), the interesting observation was made that the duration of the meiotic prophase is relatively very prolonged—as it also is (even more so) in the maturation of the oöcyte. These observations of a fixed spermatogenic time cycle are of great empirical as well as theoretical interest, since they make possible a systematic study of factors which may affect and control the different stages of spermatogenesis. A slightly different sequence of stages has been demonstrated in the monkey. But, from the point of view of future work, the most significant fact that emerged from the discussion is that no order has yet been made of the succession of cellular associations in the human seminiferous tubule.

Recent electron-microscopic observation that the four cells which are formed after the reduction division of the spermatocyte remain in a syncytial relationship with one another by means of cytoplasmic bridges excited great interest. This observation applies to every species of mammal that has so far been tested. Since cytoplasmic interchange remains possible between the spermatic cells which make up a single "clone" (sometimes more than four), the chemical products of any activity of the segregated genes could theoretically also traverse the intercellular bridges.

Another series of observations of great fundamental interest, which derive from studies in which inseminations were made with semen obtained by mixing semen from more than one male show that the varying fertility of the spermatozoa of different strains of mice are genetically determined and are generally associated with differences in the size of the sperm head. The fertility of inbred strains of mice has also been found to be considerably lower than that of outbred strains. In the course of a discussion of these findings, the meeting was wisely reminded that an assumption which is basic to all analyses of the problem of differential fertility is that all spermatozoa have the same chance of colliding with an ovum and, depending on their capacity for fertilization, of penetrating the zona pellucida and vitelline membrane. If this assumption proves false, many of our present views about the mechanisms which affect fertility and population genetics may need revision.

Male Accessory Organs

The discussions with which section 2 began its work focused on elegant electron-microscopic and other studies of the physical and chemical properties of the rete testis, ductuli efferentes, and epididymis, with particular reference to the reabsorption of the fluid medium in which the spermatozoa are transported from the testis. The role of the epididymis as an organ in which the spermatozoa undergo specific chemical and physical changes was the subject of interesting debate, which did not, however, resolve certain differences of view. When the moment came for the prostate to be discussed it was therefore not surprising to learn that, in spite of the fact that a great deal is known about the biochemistry and hormonal control of this organ, its functional significance to the whole process of reproduction remains enigmatic.

Oögenesis and Ovulation

Mysteries no less profound revealed themselves at several points in the deliberations of section 3, which dealt with oögenesis and ovulation. The weight of evidence in this field is overwhelmingly in favor of the view that, unlike the male, in whom gametogenesis is continuous, the female mammal begins her reproductive life with a fixed stock of germ cells, of which only a relatively small number ever mature and become fertilized. Practically nothing is, however, known about the process, called atresia, whereby the remainder degenerate and disappear. We know that the rate of degeneration can be retarded by means of hypophysectomy (probably as a result of the slowing down of all metabolic processes), or accelerated by means of ionizing radiations, but the physical and chemical changes which initiate degeneration of the oöcyte are so poorly understood at the moment that their visible manifestations cannot yet be clearly defined. For that reason the microscopic diagnosis of atresia, except in its advanced stages, remains arbitrary.

A series of electron-microscopic and tissue-culture studies which were presented to the meeting revealed very clearly that the granulosa cells which make up the cumulus of cells that surround the oöcyte differ, at least so far as their capacity for multiplication is concerned, from the granulosa cells which line the Graafian follicle. Their ability to proliferate in vitro seems to be determined by the degree of maturation of the oöcyte they surround. These studies could be interpreted as indicating that the separation of the cumulus cells from the mature ovum is due to detachment following death, and not, as is generally supposed, to the depolymerizing action of hyaluronidase on the hyaluronic acid by which it is presumed the granulosa cells are cemented to the zona pellucida.

The general hormonal, and particularly the local tissue, changes which are involved in ovulation remain uncertain, and our understanding of the process is not much advanced by the observation that electrical stimulation of various parts of the preoptic and adjacent hypothalamic areas of the brain of the rat leads to ovulation, whether or not the animal is in pseudopregnancy or under the "blocking" influence of substances like Nembutal. Here the difficulty is, first, that we do not know whether the hypothalamic influence is specific either anatomically or functionally, and second, that there are no facts which allow one to explain how the firing of neurons in the hypothalamus affects the behavior of the secretory cells of the pars distalis of the pituitary. All that seems certain is that they do.

Relevant to this point was the observation that oxytocin, when administered systemically on the third to sixth days of the estrous cycle of the cow will accelerate the onset of estrus and ovulation, as will also the experimental distension of the uterine horns. The latter finding implies that a nervous pathway exists whereby afferent stimulation presumably reaches the hypothalamus, whence it is translated, supposedly by some form of chemical mediation, to the anterior pituitary. If the chemical mediator or "neuroendocrine" substance involved were oxytocin, there are anatomical reasons for supposing that it could reach the pars distalis of the anterior pituitary directly from the neural process of the posterior pituitary, to which it would have passed along the axons in the pituitary stalk. Whether or not this is what happens, the observation that oxytocin produces its effects on the cycle and ovaries when given systemically makes it clear that it is unnecessary to speculate that the chemical mediator could only pass from the hypothalamus to the anterior pituitary by way of the pituitary-portal vessels.

While the precise mechanisms involved in the process of ovulation remain obscure, the timing of the event in women becomes increasingly better understood as new data accumulate. As was, however, pointed out, the various indices which imply that ovulation has occurred (for example, changes in basal body temperature) are of little predictive value in particular cases, so that it would be more correct to say that what we now know about is the period of maximum fertility in women, as opposed to knowing how to tell when ovulation is actually likely to occur in a given individual.

Sperm Physiology and Migration

The deliberations of section 4 were marked by the precision of our knowledge of the biochemistry of sperm, but, paradoxically again, by some uncertainty about the precise physiological role of the secretions of the accessory male organs. Opinion was also divided about the relationship of motility to fertility of spermatozoa, and an even greater uncertainty was manifest about the precise mechanism whereby the sperm traverses the accessory reproductive organs of the female to reach the infundibulum of the uterine tubes, where fertilization normally occurs. Since the spermatozoon is minute in relation to the distance it "travels," it is clear that its "passage" mainly implies a relative change in position, due primarily to contractions of the uterus and tubes.

Fertilization and Implantation

Fertilization and implantation, as the discussions of section 5 showed, can fortunately be treated in a less empirical way than can most other phases of the reproductive process, for here many students are already proceeding in their researches from the formulation of general hypotheses to the derivation of dependent propositions, which can then be submitted to experimental test. The phenomenon of capacitation or incubation of the sperm, which has been very closely studied by several workers, has been shown to be nonspecific from one point of view, since spermatozoa can mature almost as well on the surface of the colonic epithelium as on that of the uterus or uterine tubes. The general theory has now been put forward that the acrosome of the sperm head is normally covered by a lipoprotein which acts as a stabilizer. When the sperm head comes into contact with an epithelial surface, such as that of the uterus or uterine tubes, the lipoprotein is gradually lost, and the acrosome, which is now in an unstable state, falls away on contact with the zona pellucida, and the sperm head then penetrates the ovum.

It was possible at this stage of the discussion to oppose the new suggestion that the cumulus cells separate from the ovum simply because they "die" with the more conventional idea that hyaluronidase carried on the acrosome of the spermatozoon reacts with the hyaluronic acid of the zona pellucida. The resolution of this interesting issue clearly demands many more facts than we now have available. But once fertilization has occurred, chemistry comes in again in incontrovertible fashion, for the varying environment of the tubes plays an important part in the protection of the egg. Then comes implantation, the mechanism of which varies from species to species. In man, for example, the fertilized egg embeds itself in the uterine epithelium before the endometrial stroma has become transformed into decidua. In the rat, on the other hand, decidual formation and implantation are more closely related. The whole process has been thoroughly explored in this species on the basis of the primary hypothesis that the decidual reaction is, in the final analysis, due to the action of histamine, which is correlated with an endogenous estrogen surge, and that the whole process consists of a phase of nidus formation, followed by one of trophoblastic invasion. The formal character of this hypothesis provides a useful model for the analysis of the process in species other than the rat, as became clear from the discussion of the related issue of delayed implantation.

Some outstanding experiments by Chang on the in vitro fertilization of the egg of the rabbit were also discussed by group 5, and it was generally conceded that the evidence that the mammalian egg could be fertilized in this way was now and for the first time incontestable. Given that the experiment is easily reproducible, we therefore have available a preparation which will permit as close a study of the factors immediately involved in fertilization in mammals as is already possible in the case of lower animal forms. But the difficulty will always remain that while experiments can always be done on, say, hundreds of thousands of sea-urchin eggs at a time, it will never be possible to treat more than about 20 mammalian eggs in one single experiment.

Immunological Phenomena

The sequence of discussion of the phases of conception, from gametogenesis to implantation, stopped with the deliberations of group 5. Group 6

was concerned to see whether the principles of antibody formation and of antigen-antibody interaction, insofar as they have been established by studies over a wide field of immunology, could be applied to different aspects of the reproductive process. The general feeling was that they could, and a powerful plea that they should be so applied was made by more than one speaker. As was also pointed out, we were fortunately dealing here with a body of concepts with which many clinicians felt familiar, and with codes of practice to which they were thoroughly accustomed.

There is no doubt that the testis contains antigens which can provoke the production of antibodies, which in turn can lead to sterilization, which according to circumstances may be permanent. The testicular antigens are not completely specific, since they also occur in the brain (they have not been found in other tissues). There appear to be instances of men who have undergone a process of autoimmunization against their own testicular antigens, and as a result have become sterile. There is also an interesting possibility that in rare cases spermatozoa that fail to reach the infundibulum to take part in the fertilizing process might become incorporated in the epithelium and macrophages of the uterus, and could consequently provide a course of antigens. The meeting was, however, reminded that were this a normal process, the antigens in the spermatozoa could provoke antibody formation in the female, leading to an immunological incompatibility between spouses.

Antigens of one sort or another are probably present in various other tissues of the reproductive tract and clearly need to be investigated on planned lines. So, too, does the problem of antigonadotrophic hormones, which can today be explored by far better techniques than were available when the possibility of their existence was first proposed, in the 1930's. The relationship of blood antigens to the antigens of reproductive tissues also needs clarification. We already know that the genetic interaction of the blood-group genes can have major effects on fertility and the survival of offspring (for example, Rh incompatibility). Another application of the principles of immunology in reproductive physiology which merits further exploration is the use of steroid conjugates to block the responses of specific tissues to given steroids (for example, androgens) at the cellular level.

In addition to the use of immunologically produced antibodies as a tool for possible fertility control, there is another more subtle relation of immunological principles to the reproductive process which may have some application in the future. This is that in certain of the reproductive processes, such as fertilization (perhaps also nidation), there occur interactions of an antigen-antibody-like nature. This is exemplified by the interaction of fertilizin on the surface of the sea-urchin egg with antifertilizin on the surface of the sperm, an interaction that appears essential for the union of the gametes. Solutions of either of these substances can block fertilization, as tests with lower animals show.

Practical Aspects

In preparing this brief report it has been none too easy to select out of the mass of information that was discussed at the conference those aspects of the physiology of conception which seemed most significant from the point of view of their basic scientific interest. It is equally difficult to underline those which have, or which promise to have, a practical value in the control of conception. In the section on spermatogenesis we learned about various treatments that have a transient effect on spermatogenesis, and how, for example, ionizing radiations, so-called radiomimetic drugs, nitrofurans, and heat exert their effects at different stages of the spermatic cycle, and also how these stages correlate with those which in the normal individual are associated with the greatest incidence of cell loss. The suppression of spermatogenesis by means of androgens, and the so-called rebound phenomenon, whereby the androgenic treatment, if properly applied, is followed by the restoration of normal spermatogenesis, were also fully discussed.

In the third section, which dealt with the female gamete, and with ovulation, we heard that irradiation, if applied in sufficient doses, is associated with the total and permanent depletion of the stack of oöcytes, of which the youngest and the mature are the most sensitive to the treatment. Indices for determining when ovulation is likely to occur were, as already noted, also discussed critically. But the outstanding issue raised in this section's discussions were the results of the large Puerto Rican clinical trials, and of a few other trials in different centers, of the ovulation-suppressing effects of the 19-nor steroids. There is no doubt about the effectiveness of these compounds as inhibitors of ovulation, but as mentioned below, some hesitation was expressed because collateral reactions may have undesirable effects.

In section 5 the major practical issues discussed concerned the effect on the young zygote of antimetabolites and substances like MER 25. And almost every phase of the discussion of section 6 on immunological phenomena also seemed to have some practical bearing.

Synoptic View

The conference undoubtedly succeeded in its first aim of providing a synoptic view of the field it was designed to survey—even though many who came to see the wood also arrived with saplings in their hands. By setting our knowledge into perspective, the conference also revealed very clearly that vast areas of the subject are still cloaked in an ignorance which prevents a rational and scientific approach to the problem of population control. It was undoubtedly startling to hear expert after expert declaring that little or nothing was known about this or that subject—that, for example, we still did not know what local tissue changes are involved in the so-called rupture of a Graafian follicle, and thus in ovulation; that the processes which result in the loss of most oöcytes in the mammalian ovary are unknown; that the mechanism of the uterotubal junction is still a matter of dispute; or that one can only guess at the precise function of the prostate. The first lesson of the conference is, therefore, that it is necessary to stimulate further basic research into almost every one of the topics that were discussed. Since it is impossible to predict in advance where significant new discoveries will be made, the object of this exercise would be completely frustrated if the scientist studying basic aspects of reproductive physiology were not permitted the freedom to explore where his interest leads.

The subject, as one speaker pointed out, is still littered with legends, which, because of their presumed scientific flavor, continue to command attention. In destroying them, we need to be careful that we do not create others. All ideas have their pedigrees, and many of those which are today evolving within the field of reproductive physiology will undoubtedly become the basis of tomorrow's beliefs, and sometimes of tomorrow's practices. The responsibility of the scientist working on problems related to human reproduction is at least as great, therefore, as that of scientists working in any other field of natural knowledge. While we want more research, we particularly want more good research. Over 100 years ago Pouchét began his *Théorie Positive de l'Ovulation Spontanée* with the observation that to answer the question whether ovulation in animals occurs spontaneously he had had to apply "the three most powerful agents of the human intelligence—observation, experiment, and logic." These three—and the third no less than the other two—are still the

prerequisites of proper scientific advance. Different parts of the field covered by the conference are at different levels of scientific sophistication. Some, such as the study of atresia, are still at the stage of natural history, at the stage where simple facts have to be assembled and judged before even the most primitive hypothesis can be formulated and submitted to experimental test. Others, such as inquiries into nidation, have reached the point where the successful postulation of a general hypothesis has made it possible to subject ideas to experimental test in a logical sequence. And others again, such as the immunological matters dealt with by group 6, are in the fortunate position of being open to analysis on the basis of major scientific generalizations or hypotheses which have been established by vigorous and extensive inquiry in other fields of research.

There is nothing arbitrary in the logic of a true scientific hypothesis. It is the best general statement that can be made at a particular moment of the relation of the facts which it purports to explain. If one cannot deduce these facts from the hypothesis, the hypothesis is not a logical statement. If the hypothesis leads to experimental inquiry the results of which accord with the hypothesis, the hypothesis has been validly tested. If the hypothesis fails to do this, we may be dealing with an unfruitful generalization. And we are certainly dealing with little more than arbitrary speculation if the hypothesis contains within itself, or is coupled to, a statement which cannot be deduced from it, or which is incapable of experimental test, or which does not affect the general validity of the main idea with which it is associated. A lack of logical discipline, not surprising perhaps in view of the vast and difficult subject with which we are dealing, has encumbered our thinking with more than one illusory scientific hypothesis. We need to remind ourselves that the subject of reproductive physiology is difficult enough without our embellishing it with irrelevant speculation.

The very experimental method that physiologists pursue sometimes leads irresistibly to what is not necessarily rational conclusion. Spermatozoa withdrawn from the epididymis can be shown to be fertile; *ergo*, the secretions of the accessory reproductive organs of the male do not play an essential part in the normal processes of conception. A fertilized ovum can implant outside the reproductive tract, say, intraperitoneally; *ergo*, the uterus and uterine tubes are not essential to conception. What the conference clearly revealed was that this method of isolated observation illuminates only a small part of the picture and distorts the whole. At every turn the process of conception can be shown to be a sequential, coordinated, and overlapping series of mechanisms which seem to overinsure against any possibility of physiological breakdown. Few, if any, of the steps in the process seem to be mechanisms in which single factors are concerned. Equally, when one comes to consider the general problem of fertility, one sees that its overt and quantitative expression is the resultant of many different factors or parameters which exercise their various influences at every step in the process of reproduction.

Population Control

While deriving from a consideration of the uneven development of the basic scientific knowledge dealt with by the conference, these general observations are not without relevance to the practical problem of controlling human fertility. Many countries are now officially encouraging measures of birth control, and probably all are seeking to know of better, more natural, and culturally more acceptable methods than are now available. The search will obviously be less empirical, less "hit-or-miss," as our understanding of the scientific processes involved becomes more general and less empirical. The amount of scientific knowledge now available is clearly insufficient to predict all the effects of even such scientific methods as the suppression of ovulation by 19-nor steroids. It is not that any doubts exist about the suppression; the trouble is that it has not been established that steroids can be taken routinely over the reproductive period of a woman's life without damage or danger. We are also still uncertain about the more immediate collateral effects, which could lead to the abandonment of the method. Fortunately, clinicians far and wide are now concerned to discover what these effects are, and one result of the West Point Conference might well be to help coordinate their efforts. Such a move is urgently required, for there can be no question but that all would be better off if clinical trials of such importance were organized under auspices which would be accorded as wide an acceptance as possible. The same issues arise in every other possible application of the basic physiological knowledge discussed at the meeting. Those who take the responsibility of advocating these applications have equally to assume the burden of disposing of fears that continued use may be associated with adverse pathological and genetic effects. In this field of endeavor special responsibility is clearly in inverse ratio with the ease with which one is accustomed to assume that basic knowledge can necessarily and quickly lead to a perfect solution.

But the criterion for acceptability of a method of population control seems far more than merely the scientific certainty that what might be practiced will not have adverse clinical effects. The backscreen of the practical problem is a world in which poverty and illiteracy stalk together. What may be possible and acceptable in advanced countries is very often ruled out by these two factors alone in the less-developed areas of the world. Those countries in which the pressure of population on economic resources has led to the official endorsement of measures of birth control risk a great deal, therefore, if while waiting for the results of the physiological research discussed at the meetings they do not encourage the use of simpler and better-known methods which are within the economic and cultural reach of their peoples. This also is a conclusion which implicitly derives from the West Point deliberations.

S. ZUCKERMAN

Birmingham University, Birmingham, England

Forthcoming Events

December

4–6. American Psychoanalytic Assoc., New York, N.Y. (D. Beres, 151 Central Park West, New York 23.)

5–10. American Acad. of Dermatology and Syphilology, Chicago, Ill. (R. R. Kierland, First National Bank Bldg., Rochester, Minn.)

6. American Acad. of Dental Medicine, mid-annual, New York, N.Y. (A. J. Cannistraci, 2152 Muliner Ave., New York 62.)

6–10. American Inst. of Chemical Engineers, annual, San Francisco, Calif. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

7–12. Algology, UNESCO symp., New Delhi, India. (J. P. Correa, South Asia Cooperation Office, 21, Curzon Rd., New Delhi, India.)

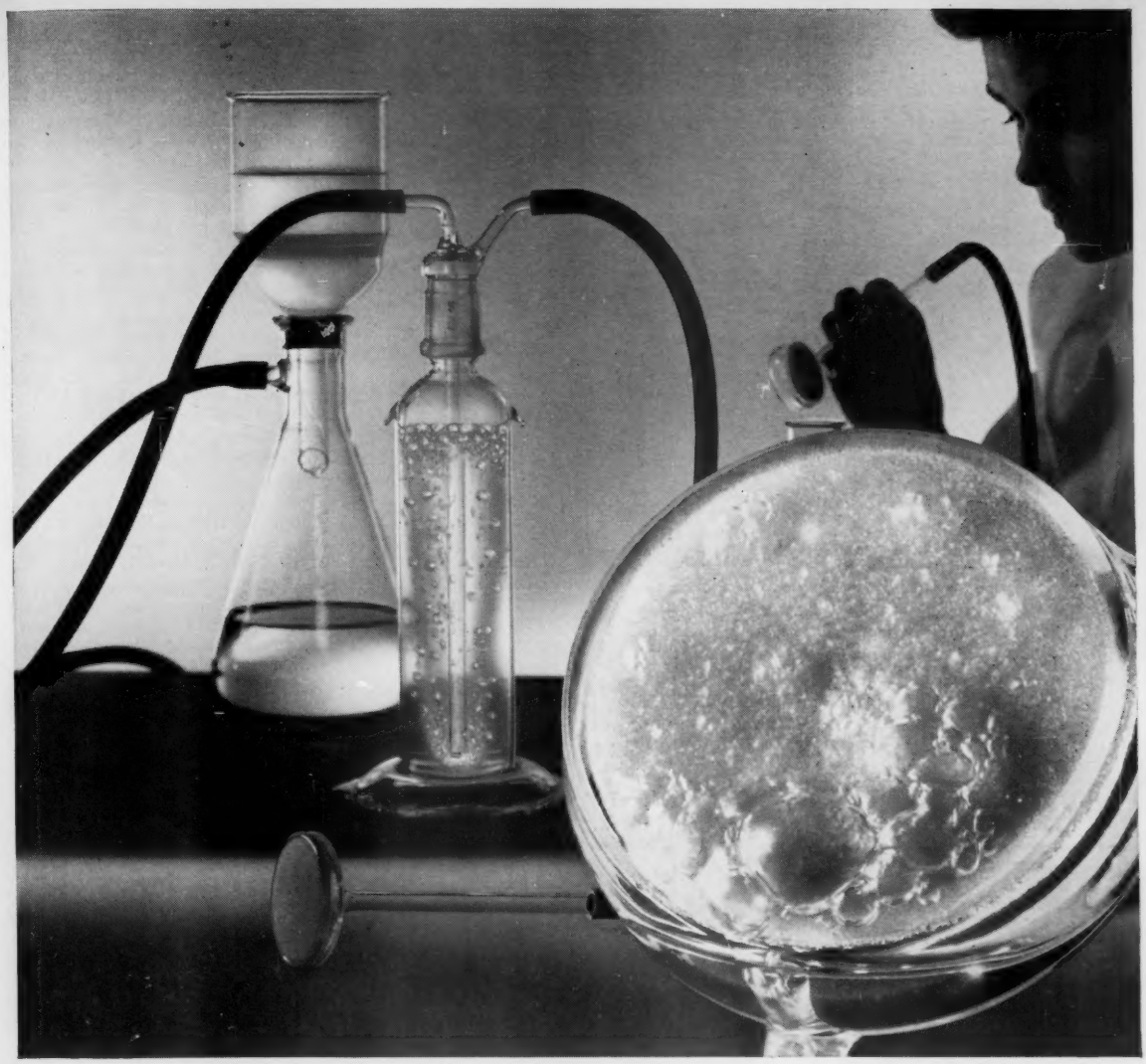
8–10. Application of Electrical Insulation, 2nd natl. conf., Washington, D.C.) (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

9–15. American Acad. of Optometry, Chicago, Ill. (C. C. Koch, 1506–1508 Foshay Tower, Minneapolis 2, Minn.)

11–12. American Rheumatism Assoc., Detroit, Mich. (F. E. Demartini, Presbyterian Hospital, 622 W. 168 St., New York 32.)

11–12. Association for Research in Nervous and Mental Disease, annual, New York, N.Y. (R. J. Masselink, 700 W. 168 St., New York 32.)

11–12. Oklahoma Acad. of Science, Weatherford. (R. Kelting, Life Sciences Department, Univ. of Tulsa, Tulsa, Okla.)



Why Pyrex fritted glassware is more efficient for filtering, extracting, gas absorption

For filtration. No need for the tedious making of asbestos filter pads. Ware can be dried quickly to constant weight at 110°C. You can *see* the filtration clearly.

For gas absorption and washing. PYREX fritted ware resists wet, corrosive gases. Intimate contact between gas and liquid phases. Low back pressure on gas line. Visibility of glass aids in judging rate of flow.

For extraction. PYREX fritted ware gives a retentive yet highly porous bed to support solids. Especially good interface for liquid-liquid extractions.

You can get a complete line of PYREX glassware that contains small discs of fritted glass—an exceptionally porous glass that acts just like filter paper, only more so. These fritted discs are sealed into the ware, so you don't have to fuss with and fold paper each time you want to work.

There are six porosities, ranging from 0.9 microns to 220 microns, from which to match your needs.

This ware is strong . . . you can use it over and over again. Backwashing or your normal chemical cleaning makes it ready for re-use. There's no fear of corrosion, since this is PYREX No. 7740 Glass.

See Catalog LG-1 and Supplement No. 3 for the complete line. For a copy of either, use the coupon.

You can include this fritted ware with your regular PYREX Labware order for maximum discounts.

CORNING GLASS WORKS
75 Crystal Street, Corning, N.Y.

Please send ☐ LG-1 PYREX Labware
☐ Supplement No. 3 to LG-1

Name.....Title.....
Company.....
Street.....
City.....Zone.....State.....

PYREX® laboratory ware . . . *the tested tool of modern research*

11–12. Salt and Water Metabolism, symp., New York, N.Y. (A. P. Fishman, New York Heart Assoc., 10 Columbus Circle, New York 19.)

11–12. Texas Acad. of Science, Austin. (L. Kennamer, Dept. of Geography, Univ. of Texas, Austin 12.)

16–18. American Soc. of Agricultural Engineers, Chicago, Ill. (J. L. Butt, P.O. Box 229, St. Joseph, Mich.)

25–27. Indian Mathematical Soc., 25th conf., Allahabad, India. (B. N. Prasad, Allahabad Univ., Lakshmi Niwas, George Town, Allahabad 2.)

26–30. American Assoc. for the Advancement of Science, annual, Chicago, Ill. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

The following 46 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Committee on Science and the Promotion of Human Welfare (B. Commoner, School of Botany, Washington Univ., St. Louis 5, Mo.). 27 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (Brother G. Nicholas, Dept. of Biology, Univ. of Notre Dame, Notre Dame, Ind.). 27 Dec.

Academy Conference (A. M. Winchester, Stetson Univ., De Land, Fla.). 27–28 Dec.

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 29 Dec.

American Assoc. of Clinical Chemists (A. Dubin, Director of Biochemistry, Cook County Hospital, Chicago 12, Ill.). 26–27 Dec.

American Geophysical Union (W. C. Krumbein, Dept. of Geology, Northwestern Univ., Evanston, Ill.). 28 Dec.

American Meteorological Soc. (K. Spengler, 3 Joy St., Boston, Mass.).

American Nature Study Soc. (E. L. Will. State Univ. Teachers College, Oneonta, N.Y.). 26–30 Dec.

American Physiological Assoc. (F. A. Hitchcock, Ohio State Univ., Columbus). 28 Dec.

American Political Science Assoc. (J. Robinson, Dept. of Political Science. Northwestern Univ., Evanston, Ill.). 28 Dec.

American Psychiatric Assoc. (E. L. Bliss, General Hospital, Salt Lake City, Utah). 28–29 Dec.

American Soc. of Criminology (D. E. J. MacNamara, New York Inst. of Criminology, Inc., New York 36). 28–29 Dec.

American Soc. of Naturalists (A. D. Hasler, Dept. of Zoology, Univ. of Wisconsin, Madison). 27–28 Dec.

American Soc. of Plant Taxonomists (L. R. Heckard, Dept. of Botany, Univ. of Illinois, Urbana). 28–30 Dec.

American Sociological Soc. (J. S. Coleman, Dept. of Sociology, Univ. of Chicago, Chicago 37, Ill.). 28–29 Dec.

American Statistical Assoc. (R. F. Winch, Dept. of Sociology, Northwestern Univ., Evanston, Ill.). 29–30 Dec.

Association of American Geographers (A. Cutshall, Univ. of Illinois, Navy Pier, Chicago 11). 29 Dec.

Association for Computing Machinery (W. F. Cahill, Goddard Space Flight Center, Silver Spring, Md.). 29 Dec.

Astronomical League (E. Halbach, 2971 S. 52 St., Milwaukee 19, Wisc.). 26 Dec.

Beta Beta Beta (Mrs. F. G. Brooks, P.O. Box 515, Ansonia Station, New York 23). 27–28 Dec.

Chicago Acad. of Sciences (R. A. Edgren, Chicago Acad. of Sciences, 2001 N. Clark St., Chicago 14, Ill.). 29–30 Dec.

Conference on Scientific Communications (G. L. Seielstad, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.). 28–29 Dec.

Conference on Scientific Manpower (T. J. Mills, National Science Foundation, Washington 25). 28 Dec.

Ecological Soc. of America (W. C. Ashby, Dept. of Botany, Univ. of Chicago, Chicago 37, Ill.). 28–30 Dec.

Honor Soc. of Phi Kappa Phi (L. R. Guild, 634 S. Western Ave., Los Angeles 5, Calif.). 30–31 Dec.

Illinois Geographical Soc. (Miss M. Grant, Morton Junior College, Cicero, Ill.). 28 Dec.

Institute of Management Sciences (M. M. Flood, College of Engineering, Univ. of Michigan, Ann Arbor). 29 Dec.

Metric Assoc. (J. T. Johnson, Ravenswood YMCA, 1725 Wilson Ave., Chicago 40, Ill.).

Mycological Soc. of America (D. P. Rogers, Dept. of Botany, Univ. of Illinois, Urbana).

National Assoc. of Biology Teachers (H. E. Weaver, 202 Men's Old Gym, Univ. of Illinois, Urbana). 26–30 Dec.

National Acad. of Economics and Political Science (J. Rothrock, Pan American Union, Washington 6). 29 Dec.

National Assoc. for Research in Science Teaching (J. C. Mayfield, Univ. of Chicago, Chicago 37, Ill.). 26–30 Dec.

National Assoc. of Science Writers (P. Fraley, Evening Bulletin, Philadelphia, Pa.). 27 Dec.

National Geographic Soc. (W. R. Gray, NGS, 16 and M Sts., NW, Washington 6). 30 Dec.

National Science Teachers Assoc. (R. H. Carleton, NSTA, 1201 16 St., NW, Washington, D.C.). 26–30 Dec.

National Soc. for Medical Research (R. A. Rohweder, NSMR, 920 S. Michigan Blvd., Chicago 5, Ill.). 29 Dec.

National Speleological Soc. (T. C. Barr, Jr., Tennessee Polytechnic Inst., Cookeville, Tenn.). 28 Dec.

Philosophy of Science Assoc. (W. A. R. Ley, Roosevelt College, Chicago, Ill.). 28 Dec.

Scientific Research Soc. of America (D. B. Prentice, 56 Hillhouse Ave., New Haven 11, Conn.). 29 Dec.

Sigma Delta Epsilon (Miss E. S. Anderson, Stratford Hotel, 25 E St., NW, Washington, D.C.). 26–30 Dec.

Society for General Systems Research (R. L. Meier, Mental Health Research Institute, Univ. of Michigan, Ann Arbor).

Society for the History of Technology (M. Kronzberg, Dept. of History, Case Inst. of Technology, Cleveland, Ohio).

Society of the Sigma Xi (T. T. Holme, 56 Hillhouse Ave., New Haven 11, Conn.). 29 Dec.

Society of Systematic Zoology (R. E. Blackwelder, Southern Illinois Univ., Carbondale). 26–30 Dec.

Tau Beta Pi Assoc. (R. H. Nagel, Univ. of Tennessee, Knoxville). 27 Dec.

United Chapters of Phi Beta Kappa (C. Billman, 1811 Q St., NW, Washington, D.C.). 29 Dec.

27–30. American Anthropological Assoc., Mexico City. (W. S. Godfrey, Jr., Logan Museum, Beloit College, Beloit, Wisc.)

27–30. American Astronomical Soc., Cleveland, Ohio. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

27–30. American Folklore Soc., Mexico City. (MacE. Leach, 110 Bennett Hall, Univ. of Pennsylvania, Philadelphia 4.)

27–30. American Statistical Assoc., Washington, D.C. (D. C. Riley, 1757 K St., NW, Washington 6.)

27–30. Institute of Mathematical Statistics (weather control), Washington, D.C. (J. Neyman, Statistical Lab., Univ. of California, Berkeley 4.)

28–29. American Chemical Soc. (Div. of Industrial and Engineering Chemistry), symp., Baltimore, Md. (M. A. H. Emery, ACS, 18 and K Sts., NW, Washington D.C.)

(See issue of 16 October for comprehensive list)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to* Science, *Room 740, 11 West 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

■ CONDUCTIVITY METER for nonmagnetic metals is a portable, battery-powered, transistorized instrument that operates by inducing eddy currents within the material being measured. The instrument reads conductivity from 8 to 107 percent of the International Annealed Copper Standard. Accuracy is said to be ±3 percent of scale reading. (Magnaflux Corp., Dept. 178)

■ SAMPLE HOLDER for metallographic preparations accommodates up to six specimens simultaneously for grinding and polishing. Adapters permit specimens to be of different diameters. Insertion does not involve clamping, and samples can be removed during processing. The relative movement of disk and specimen is regulated by a liquid brake. (William J. Hacker & Co., Dept. 181)

■ VOLTMETER for panel mounting has input impedance 5 megohm paralleled by 25 pf. Full-scale ranges extend from 10 mv to 300 volts r.m.s. Frequency range is 20 cy to 200 kcy/sec with accuracy ±2 percent of full scale. The effect of ±10 percent variation in line voltage is within ±1 percent. (Metronix, Inc., Dept. 182)

■ ELECTRON-BEAM WELDER for welding reactive metals in high vacuum operates by directing a beam of high-energy electrons onto the work from a gun positioned at the top of the welding chamber. Beam current is 0 to 100 ma at 0 to 10 or 0 to 20 kv. A work table can be moved longitudinally and rotated without breaking the vacuum. Pump-down time is 8 min. Maximum welding speed is ½ in./sec longitudinally and 5 rev/min for circular welds. Circular welds up to 8 in. in diameter and longitudinal welds up to 4-in. long can be made without modifying the unit. (NRC Equipment Corp., Dept. 183)

■ GAMMA IRRADIATOR provides an average dose rate of 200,000 r/hr in a chamber 2.5 in. in diameter and 9 in. deep. The central chamber is surrounded by a cylindrical metal assembly containing the radioactive source. Around this assembly are wound two bonded stainless-steel coils, one to carry fluid samples, the other to carry heating or cooling fluids. A layer of thermal insulation and 9-in.-thick lead shielding surround the coils. (Victoreen Instrument Co., Dept. 190)

■ PORTABLE OSCILLOSCOPE, transistorized, will operate up to 3 hr on ten high-current, size D, flashlight cells and up to 6 hr on rechargeable cells. It will also operate on line power. Specifications are: vertical passband, d-c to 5 Mcy/sec; rise time, 0.07 μsec, deflection factor, 10 mv/div; sweep range, 0.5 μsec to 0.5 sec/div in 19 steps; triggering, fully automatic or preset with amplitude-level selection. Amplitude calibration is provided. Weight is 12 lb, size 5¼ by 8¼ by 16 in. (Tektronix, Dept. 204)

■ REFERENCE VOLTAGE SOURCE is variable from 0 to 600 volts in steps of 0.1 mv. Fluctuation due to line-voltage variation between 90 and 135 volts is said to be less than 2 parts in 10^6; drift ±3 parts in 10^5 per day under laboratory conditions. Voltages are set by four decade output switches and a fine adjustment control. (Gyra Electronics Corp., Dept. 186)

■ NEAR-INFRARED FILTERS of interference type commence to transmit at wavelengths up to 1.2 μ. The filters use evaporated films of silicon and magnesium fluoride. Operating temperature range is −40° to +100°C. Diameters up to 6 in. are available. (Metavac, Inc., Dept. 188)

■ THERMISTOR PROBES are offered with matched resistance-temperature characteristics in any quantity. Absolute resistance of each probe is given in increments of 1°F from 0° to 350°F. Probes are said to be within ±2 percent of nominal resistance at any point in the range. (Fenwal Electronics, Dept. 196)

■ DIGITAL OHMMETER for low-resistance measurement is said to be accurate to ±1 mohm over the range 1 to 9999 mohm. Sensitivity of 100 μohm is available with reduced accuracy. Scanning and print-out modules can be added. (Electro Instruments, Dept. 194)

■ CENTRIFUGE incorporates into one end of its rotating boom a hydraulic vibration system capable of 0.5-in. double amplitude and acceleration level up to 20 *g* from 5 to 500 cy/sec. A 12-in. cube weighing 40 lb can be supported. (Genisco, Dept. 195)

■ INSULATION TESTER measures leakage current as low as 0.05 μa and up to 2000 μa with d-c test potentials continuously variable from 0 to 5000 volts. Operation is on 115-volt a-c power. Weight is 24 lb, size 13½ by 13 by 7 in. (Associated Research, Dept. 203)

JOSHUA STERN

National Bureau of Standards, Washington, D.C.

APPLICATION FOR HOTEL RESERVATIONS

126th AAAS MEETING

Chicago, 26-31 December 1959

The four hotels for the AAAS Chicago meeting have established special low rates and have reserved large blocks of rooms at each level within the price ranges quoted. Thus everyone making room reservations for the AAAS meeting is assured substantial savings. Further, all confirmations will state the room rate assigned.

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel reservation in Chicago. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in Chicago and thereby avoid delay and confusion. The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less.

If desired, the hotels will add a cot at $3.00 per night—except that all children under 12 are free. Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Rates for Rooms with Bath* *No sessions in public rooms.* For a list of the headquarters of each participating society and section, see page 228, *Science*, 24 July.

Hotel	Single	Double Bed	Twin Bed	Suite
Morrison	$6.50— 9.00	$9.00—13.00	$11.00—15.00	$30.00 and up
Hamilton	6.50— 9.50	9.00—13.00	11.00—15.00	25.00 and up
La Salle	7.50—10.00	10.50—13.00	12.50—15.50	35.50 and up
Sherman	7.45—12.45	11.45—16.45	14.45—19.50	28.50 and up
*Bismark	6.50—10.00	9.00—13.00	11.00—15.00	

THIS IS YOUR HOUSING RESERVATION COUPON

AAAS Housing Bureau
Suite 900
134 North La Salle Street
Chicago 2, Ill.

Date of Application .....

Please reserve the following accommodations for the 126th Meeting of the AAAS in Chicago, 26-31 Dec., 1959:

TYPE OF ACCOMMODATION DESIRED

Single Room ..... Desired Rate ..... Maximum Rate .....

Double-Bedded Room ..... Desired Rate ..... Maximum Rate ..... Number in party .....

Twin-Bedded Room ..... Desired Rate ..... Maximum Rate .....

Suite ..... Desired Rate ..... Maximum Rate ..... Sharing this room will be:

(Attach list if this space is insufficient. The name and address of each person, including yourself, must be listed.)

.....

.....

First Choice Hotel ..... **Second Choice Hotel** ..... **Third Choice Hotel** .....

DATE OF ARRIVAL ..... DEPARTURE DATE .....
(These must be indicated—add approximate hour, a.m. or p.m.)

NAME .....
(Individual requesting reservation) (Please print or type)

ADDRESS .....
(Street) (City and Zone) (State)

Mail this now to the Housing Bureau. Rooms will be assigned and confirmed in order of receipt of reservation.

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted, 25¢ per word, minimum charge $4. Use of Box Number counts as 10 additional words. Payment in advance is required. Positions Open, $33 per inch or fraction thereof. No charge for box number.

COPY for classified ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Rates listed below—no charge for Box Number. Monthly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	**$33.00 per inch**
4 times in 1 year	**30.00 per inch**
7 times in 1 year	**28.00 per inch**
13 times in 1 year	**27.00 per inch**
26 times in 1 year	**26.00 per inch**
52 times in 1 year	**25.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

(a) **Young Biochemist**, Ph.D.; assistant professor in medical school, 3 years; clinical research biochemist in large hospital, 3 years; prefers clinical, enzymology and protein chemistry research; (b) **Ph.D.**, mycology major, bacteriology-biochemistry minors; microbiology group leader on enzyme and fermentation research; desires research with agricultural or pharmaceutical company. Medical Bureau, Inc., Burneice Larson, President, 900 North Michigan, Chicago. X

Medical Mycologist, Ph.D. Training, experience with fungi, atypical mycobacteria. Genetics. Box 243, SCIENCE. X

Virologist, Ph.D. Interested viral tumor program. Experienced tissue culture, phage transduction. Box 244, SCIENCE. X

POSITIONS OPEN

Analytical Chemist. Position in pharmaceutical research control group for company producing ethical line of veterinary pharmaceutical and biological products. Duties include control of and assisting in the development of new control procedures for pharmaceutical products produced by the company. Excellent growth opportunity for qualified man possessing B.S. degree in chemistry. Contact Personnel Manager, Jensen-Salsbery Laboratories, Inc. (a subsidiary of Vick Chemical Company), 21st and Penn, Kansas City 41, Missouri. 10/30; 11/6

POSITIONS OPEN

We invite applications from *all-level*
LIFE AND PHYSICAL SCIENTISTS
Write Dr. A. H. Hammond
Box 2707, Wash. 13, D.C.
Visit Booth 42, AAAS Meeting!

Assistant Clinical Chemist. Masters' degree in biochemistry or bachelor's degree in chemistry plus experience. Will assist in supervision of clinical chemistry laboratory, performance of special tests, and teaching of students. Accredited 400-bed hospital, large eastern city. Box 240, SCIENCE. 11/6, 13

Assistant Secretary, Council on Drugs. M.D. or Ph.D. in pharmacology, to assist in the council's drug-evaluation program, preparation of reports on new drugs and of *New and Nonofficial Drugs* and other council publications. Experience in medical writing desirable but not essential. Salary commensurate with background and experience. Send full résumé to Dr. H. D. Kautz, Secretary, Council on Drugs, American Medical Association, 535 North Dearborn Street, Chicago 10, Illinois. X

(a) **Bacteriologist**; Ph.D. to conduct basic research infectious diseases, participate study, development synthetic drugs; prominent eastern concern; to about $10,000. (b) **Chemist**; degree to supervise section, teach students, perform complicated procedures; 300-bed general hospital; $6300; mid-eastern college city. (c) **Pharmacologist**; Ph.D. to establish evaluation program associated toxicity studies in new screening; to $8500; pharmaceutical concern near Chicago. (d) **Bacteriologist**; M.S. preferred to head department, expanding, progressive laboratory, 350-bed general hospital; minimum $7500; southeastern college city. (e) **Biochemist**; Ph.D. interested molecular biology, experienced tissue culture techniques and/or virology; research section, prominent southwestern university medical center hospital; to $9000. Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash Avenue, Chicago. X

(a) **Biochemist**, Ph.D., for fundamental research in microbiological chemistry, especially proteins and nucleic acids. (b) **Organic Chemist**, Ph.D., for fundamental research in the constitution of natural steroid products. Write, submitting résumé of experience and references, to Dr. H. Sobotka, Department of Chemistry, Mount Sinai Hospital, New York 29. Telephone: TRafalgar 6-1000, Ext. 8061. X

Experimental Psychology Assistantships. Animal studies. Use operant and Pavlovian conditioning techniques, treat data, maintain animals, assemble apparatus. On-job training. Salaries between $4000 and $5000. Inquire Chief, Experimental Psychology Laboratory, Creedmore Institute for Psychologic Studies, Queens Village 27, N.Y. 11/6

Jensen-Salsbery Laboratories, Inc., manufacturer of pharmaceutical and biological products, offers two new appointments:

1. **Bacteriologist or Virologist**
   Applications are invited from microbiologists with laboratory experience in bacteriology or virology. Requirements are a master's degree or doctorate in a microbiological science and several years' laboratory experience. Experience in immunology and concerntration of blood protein factor is desirable but not essential. The successful applicant would assist in supervising the manufacture of immunological products and also carry out research and development work on existing and new products.

2. **Microbiologist (Tissue Culture)**
   Graduates in microbiology are invited to apply for a position in the tissue culture laboratory. Applicants should possess a degree in bacteriology or other biological science and have postgraduate experience in microbiology. Experience in tissue culture techniques is desirable but not essential. The successful applicant would assist in the manufacture of tissue culture virus products and the development of new virus and other vaccines prepared in tissue culture systems.

These positions are with a rapidly expanding company and offer excellent opportunities for personal growth. Initiative and the ability to contribute ideas are essential qualifications for these appointments. Apply, giving a concise summary of qualifications and experience, to the Personnel Manager, Jensen-Salsbery Laboratories, Inc. (a subsidiary of Vick Chemical Company), 21st and Penn, Kansas City 41, Missouri.

RESEARCH OPPORTUNITIES in

SPACE SCIENCES

The Space Technology Operations of Aeronutronic has immediate need for engineers and scientists who are interested in working in the stimulating and highly diversified field of space sciences. This West Coast division of Ford Motor Company has the newest facilities and most advanced equipment for carrying out highly technical work—challenging creative work that is exceptionally rewarding to qualified men.

Positions are at Aeronutronic's new $22 million Research Center, being completed at Newport Beach, Southern California. Here, overlooking famous Newport Harbor and the Pacific Ocean, relaxed California living can be enjoyed free of big-city congestion, yet most of the important cultural and educational centers are just a short drive away.

AREAS OF INTEREST

VEHICLE TECHNOLOGY
- Aerodynamic design and testing
- Rocket Nozzle and re-entry materials
- High temperature chemical kinetics
- Combustion thermodynamics
- High temperature structural plastics and ceramics
- Advanced structures

SYSTEMS DEVELOPMENT
- Aerothermodynamics
- Re-entry programs
- High temperature heat transfer
- Penetration systems
- Hyper environmental test systems

ELECTRONICS AND ASTRO SCIENCES
- Astro navigation
- Space communications and communication satellites
- Instrumentation, telemetering and data reduction
- Space enivronmental physics
- Advanced techniques and system studies

Qualified applicants are invited to send resumes and inquiries to Mr. R. W. Speich, Aeronutronic, Dept. 16, Box 451, Newport Beach, California.

AERONUTRONIC
a Division of Ford Motor Company
Newport Beach
Santa Ana • Maywood, California

POSITIONS OPEN

Bacteriologist Technician. Opportunity for technician in clinical medicine research for an ethical company producing pharmaceutical and biological products. Position involves testing and aiding in the development of new products in cooperation with the research veterinarians. Good growth potential for man with B.S. degree in bacteriology. Contact Personnel Manager, Jensen-Salsbery Laboratories, Inc. (a subsidiary of Vick Chemical Company), 21st and Penn, Kansas City 41, Missouri. 10/30; 11/6

BIOCHEMIST—Ph.D. or M.S.

Immediate opening in biochemical development for a man trained in antibiotic and natural product isolation. Strong background in organic and fermentation chemistry desirable. Opportunities for accomplishment and advancement. Send résumé of education and experience to

EMPLOYMENT DIVISION
ABBOTT LABORATORIES
NORTH CHICAGO, ILLINOIS

Biologist, Histologist, Histochemist, Ph.D. or equivalent. Research institute, New York, to work in the field of experimental diabetes. Box 235, SCIENCE. 10/30; 11/6

Herbicides Biologist; Ph.D. (0 to 5 years' experience) to be project leader of laboratory devoted to plant growth-regulatory research with primary emphasis on screening and evaluating for new herbicides. Plant physiology and/or agronomy are desirable major disciplines with biochemistry and morphology as minors. Write Research Director, Niagara Chemical Division, Middleport, New York, for application for employment blank. eow

PHARMACEUTICAL DEVELOPMENT DIVISION
of a
NORTHERN NEW JERSEY PHARMACEUTICAL COMPANY

is seeking ambitious section heads for this aggressively expanding department. Key positions now open:

HEAD OF TABLETING AND COATING SECTION

Ph.D. preferred but not essential. Significant related practical experience.

HEAD OF EXPLORATORY PHARMACEUTICAL RESEARCH

Ph.D. essential, preferably in physical chemistry. Truly creative man with related experience in drug field. Please send detailed résumé in complete confidence. All replies will be acknowledged. Our employees know of this ad.

Box 239, SCIENCE

Pharmacologist, Ph.D., and **Biochemist,** Ph.D. Some experience helpful but not essential. Opportunities for creative research in growing, pharmaceutical laboratory. Close departmental relationship with creative chemical group. New laboratories to be completed in spring; some positions available now. Replies held confidential. Send résumés to Research Department, Irwin, Neisler & Co., Decatur, Illinois. 11/6

(a) **Senior Pharmacologist** to head new drug and evaluation program of midwestern drug firm, $15,000; (b) **Biochemist** to direct pilot plant producing hormones for endocrinology investigators, conduct own research, have staff appointment at large university, $8000; (c) **Public Health Inspector** for foreign operation of large oil company; M.S. or Ph.D. degree in public health or similar areas; 2-year contract; around $10,000–$13,000 per year. (d) **Export Staff Assistant,** read and write Spanish, service salesman, answer correspondence, receive foreign visitors; pharmaceutical firm in East; $7000; (e) **Bacteriologist-Virologist,** M.S. or D.V.M., assist in supervising manufacture of immunological products and conduct research, Midwest, $7500–$8500 per year; S11-1 Medical Bureau, Inc., Burneice Larson, President, 900 North Michigan Avenue, Chicago. X

POSITIONS OPEN

Pharmacologist

Position now available in our laboratories for young Ph.D.-level scientist with 3 to 5 years' recent experience in cardiovascular research.

Kindly send curriculum vitae
to PERSONNEL DIRECTOR

SCHERING CORP.
Mfr. of Fine Pharmaceuticals
60 Orange St. Bloomfield, N.J.

Postdoctoral Traineeships in Enzyme Chemistry are available for 1960–61 at the University of Wisconsin, Institute for Enzyme Research in Madison. Applications may be submitted at any time and are invited from candidates who have completed or will shortly complete the requirements for either the Ph.D. or M.D. degree and who are U.S. citizens. The period of traineeship is 12 months (including 1 month's vacation) and may be renewed for additional years. Stipends are $6000 per year and, in most cases, partially tax exempt. A travel allowance is provided the trainee from his present institution (if within continental United States) to Madison. Senior traineeships are available to persons who by virtue of previous postdoctoral training and/or experience have demonstrated outstanding ability. Application forms and information may be obtained by writing to Dr. David E. Green, Program Director. 12/4

Science Teachers, Librarians, Administrators urgently needed for positions in many states and foreign lands. Monthly non-fee placement journal since 1952 gives complete job data, salaries. Members' qualifications and vacancies listed free. 1 issue. $1. Yearly (12 issues) membership, $5. CRUSADE, SCI., Box 99, Station G, Brooklyn 22, N.Y. ew

Virologist. Masters degree with virus training and 2 years' experience. Salary $440 to $550. Also opening for **Bacteriologist** with masters degree or 1 year's experience. Salary $400 to $550. Entrance steps dependent on qualifications. For work under experienced virologist in diagnostic and research activities in well-equipped State Virus Laboratory, State Board of Health, Helena, Montana. 11/13, 20, 27

FELLOWSHIPS

Postgraduate Fellowship for study of micro-organisms involved in cellulose decomposition. Annual stipend $2500 for at least 3-year period. Applications with curriculum vitae and names of two references should be sent to Head, Botany Department, University of Western Ontario, London, Canada. X

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Monthly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	$33.00 per inch
4 times in 1 year	30.00 per inch
7 times in 1 year	28.00 per inch
13 times in 1 year	27.00 per inch
26 times in 1 year	26.00 per inch
52 times in 1 year	25.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

BOOKS AND MAGAZINES

SCIENTIFIC JOURNALS WANTED
Sets, Runs and Volumes bought at top prices. Your wants supplied from our Back Files of over 3,000,000 periodicals. Abrahams Magazine Service; N. Y. 3, N. Y.

BOOKS AND MAGAZINES

Your sets and files of scientific journals

are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

PROFESSIONAL SERVICES

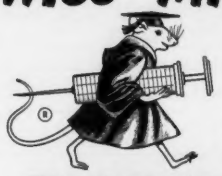
HISTOLOGY
for
Industry and Research
GEORGE L. ROZSA, M.D.
143 Linwood Ave. Buffalo 9, New York
GRant 7165

WISCONSIN ALUMNI RESEARCH FOUNDATION

LABORATORY SERVICES
for the FOOD, FEED, DRUG and CHEMICAL INDUSTRIES
Analyses, Biological Evaluation, Toxicity Studies, Insecticide Testing and Screening, Flavor Evaluation.
Project Research and Consultation
Write for Price Schedule
P. O. Box 2217 • Madison 1, Wis.

SUPPLIES AND EQUIPMENT

SWISS MICE



Send for booklet

TACONIC FARMS
GERMANTOWN NEW YORK

YOU NEED THIS **FREE** CATALOG FOR YOUR FILES

Serums, antiserums and bloods of all kinds for technicians and tissue culture laboratories. No salesman will call.

COLORADO SERUM CO.
4950 York St. • MAin 3-5373 • Denver 16, Colo.

SWISS MICE
BACTERIOLOGICAL AND GROSS TISSUE STUDY TECHNIQUES USED IN OUR QUALITY CONTROL
HUNTINGDON FARMS, INC.
2548 NORTH 27th ST. PHILA. 32, PA.

M I C E
SWISS INBRED
HYPOPHYSECTOMIZED
GREEN HILLS FARM
Box 381, Jeffersonville, New York Tel.: 363

Frontiers are extended by the practical visionary

It is the practical visionary who has given us much of what we enjoy today. And it will be the visionary—the man with ability to seek concepts beyond the existing limitations of science—who will guide our developments of tomorrow.

The Applied Physics Laboratory (APL) of The Johns Hopkins University seeks men who will be engaged in advanced research problems—who will find solutions to problems yet to be posed. Their findings will provide guidelines for the space and missile hardware research of the future.

Your endeavors will be heightened by the professional atmosphere of APL. This atmosphere, created by men dedicated to the furtherance of science, has earned APL a reputation as a leader in programs vital to the national security.

Appointments at APL offer exceptional opportunities. For detailed information, address your inquiry to:

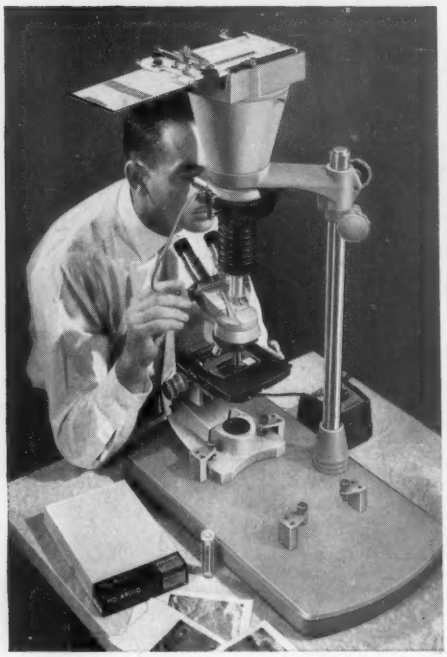
Professional Staff Appointments

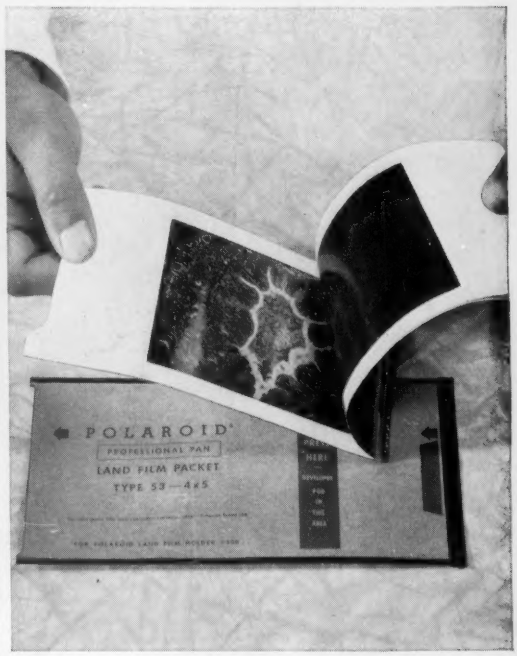
The Johns Hopkins University Applied Physics Laboratory

8615 Georgia Avenue, Silver Spring, Maryland

NOW! Snap it... See it...

IN BIG POLAROID LAND 4" x 5" PRINTS





AO Spencer Photomicrographs
...just 60 seconds from snap to finish

Now your AO Photomicrographic Camera can be equipped with the new Polaroid Land Film Holder to give you big 4"x5" finished, glossy prints... ready for your files... in just 60 seconds. A coupled visual and photographic system allows you to shoot exactly what you see... instantly and effortlessly. Processing of the picture takes place right in Polaroid's 4"x5" Holder, thus possible errors in exposure, illumination or focus can be rectified immediately.

If you prefer, you have a wide choice of 5 other readily interchangeable camera backs; the Polaroid Land Camera Back for roll film, paper prints and transparencies, 4" x 5" fixed back, 4" x 5" Graflok back, 35mm back and Bantam (roll film) back. You choose the camera back and film best suited to your specific requirements.

This new "Big-Size" 4" x 5" Polaroid Film Holder is available from your industrial photographic supplier.

Here, the No. 682G Camera being used with the AO Spencer Series 4 Microstar proves an ideal combination. The built-in base illuminator provides convenient Koehler-type illumination. You select specimen area and do all preliminary focusing through binocular portion of trinocular body... focus critically with the telescopic eyepiece.

The sturdy vertical pillar, the easily adjustable camera support, the camera back and the Microstar all combine to provide a compact unit in precise, rigid alignment. Successful photomicrography becomes a "snap".

Try it and see for yourself. Your AO Representative will be happy to arrange a convincing demonstration for you.

SPENCER

American Optical Company

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK

Dept. W-1

☐ Please send me Brochure SB682 describing the entire line of AO Spencer Photomicrographic Cameras.

☐ Please send me Brochure SB124 describing the new Microstar line.

Name _____

Address _____

City _____ Zone ____ State _____